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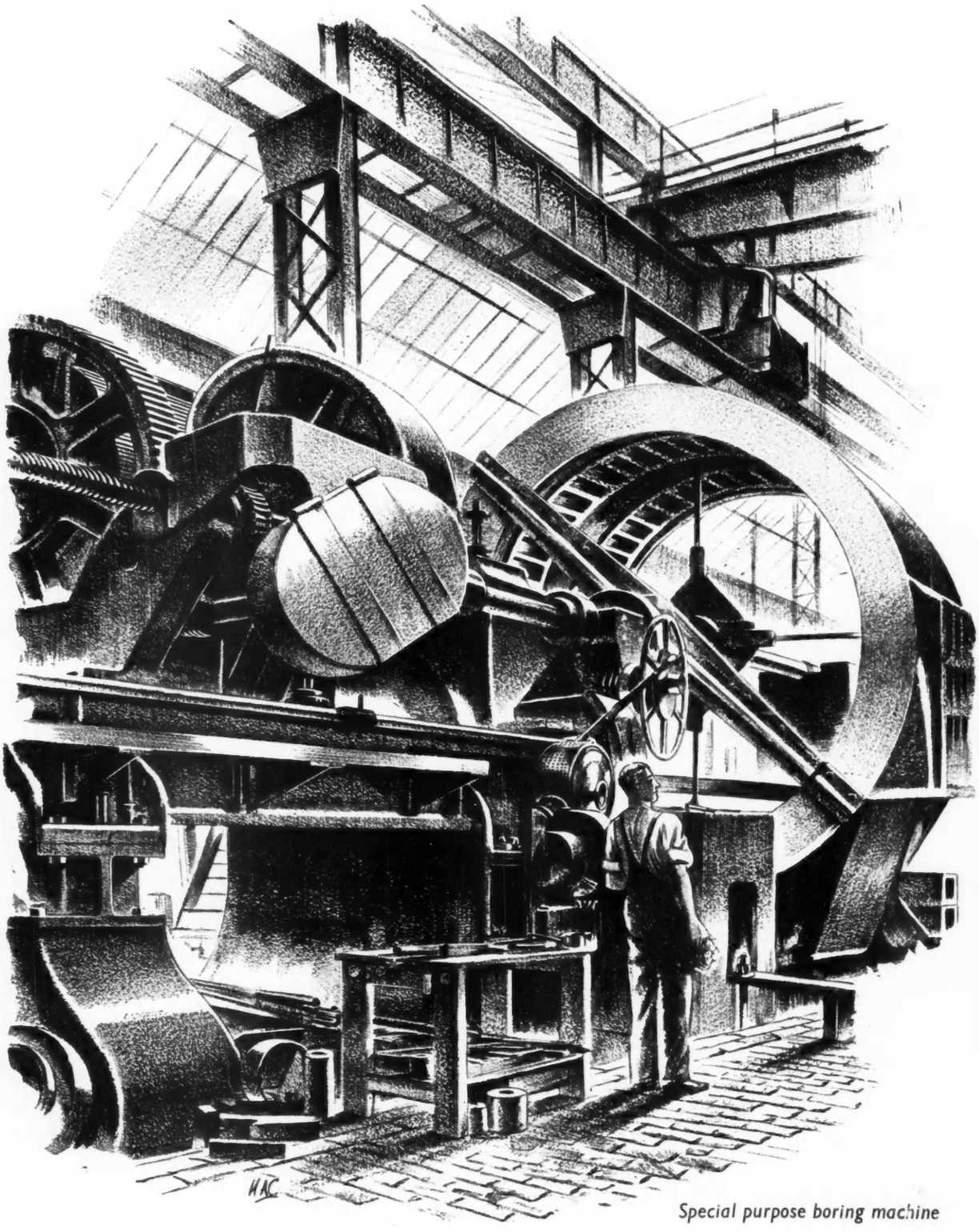

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THE STATIC HAZARD IN INDUSTRY.

By GEORGE MORRIS.

In many industrial operations, particularly in the chemical industry, electrostatic charges are generated and accumulate on the plant and the material being processed. In some industries, such as cotton spinning or paper making, the effect of such charges is a more or less serious nuisance, rendering the handling of the product more difficult, or giving electric shocks to the operators. In other industrial processes, where inflammable or explosive materials have to be handled, the presence of electrostatic charges constitutes a hazard of fire or explosion. As examples of such processes may be cited the handling of solvents in petrol distribution and in the dry-cleaning industry; the preparation of fine powders, as in flour milling or the manufacture of metallic dusts; the use of anæsthetics in surgery; and the manufacture of explosives.

In view of the grave dangers to life and property involved, the static hazard has received considerable study, but the writer is not aware of any published method by which the limits for plant safety of leak resistances and the like can be calculated. In the present article, a simple procedure for making such calculations for any specific set of circumstances is set out, together with a summary of the evidence on which that procedure is based. It should be noted that dangerous conditions for spark-type ignitions can be readily set up by a faulty condition of electrical appliances; but these are not considered in this survey.

Electrostatic charges can be generated by a wide variety of industrial operations involving the formation or rearrangement of surfaces of insulating materials; for example, the passage of wet vapours through jets, grinding, the transport of dusts, or the running of belts. The exact mechanism by which these charges are generated has been extensively discussed in the literature, but is still far from clear. Owing also to the great influence of small changes in atmospheric conditions, generated by any operation, the published magnitudes of the charges to be expected differ widely; sometimes the very sign of the charge is reversed. In practice, it is a matter of great difficulty to estimate with any precision the charge which will be generated in any manufacturing process. Fortunately, however, the rate of charge can usually be measured to a sufficient accuracy by using simple methods and apparatus as those to be described. It is desirable, however, in studying any process to know what operations in it are likely to generate charges, and the following notes are intended as a guide in such a study. An extensive examination of this subject has been published in America by P. G. Guest.*

Persons generate charges by the friction of their clothing, and of their footwear on the ground, and the rate of charging may be as high as 10^{-7} ampere. In dry atmospheres, and when conventional rubber footwear is worn, such charges may be sufficient to raise the potential of workpeople to voltages sufficient to administer severe electric shocks on touching earthed objects.† It must be emphasised that such a charged person is quite unaware of his high potential until discharge occurs.

Dry fabrics, such as cotton, cloth or paper, may acquire very large charges during processing, particularly when long lengths are run over heated metal rolls. While the electrostatic charges so generated do not, in general, constitute a hazard of fire, the charges are very objectionable as they may cause the cloth to "stick" together so as practically to prevent manipulation. They may also cause fluff and dust to adhere to the fabric and so spoil its quality. The motion of insulating powders either in pouring, sieving or mixing, can generate substantial charges.‡

Dust suspensions in air may carry very large electrical charges.§ This subject has been studied by A. Nakaya and T. Terada,‖ who have shown that the charge is produced largely by friction. As the dust cloud cannot be a good conductor, even if its particles are metallic, an incendiary discharge cannot pass to the cloud itself. Risks occur if, at any point in its passage, the cloud passes over ungrounded conductors which may acquire substantial charges. Simpson,¶ in a theory of thunderstorms, considers that, provided the particles of the cloud are conducting and at a sufficiently high potential, a spark can pass from a cloud to an earthed conductor. It is doubtful, however, if sufficiently high potentials are generated in industrial operations.

In crushing, grinding and mixing, considerable charges may be generated. Sulphur is particularly susceptible to static formation. Similarly, in the drying of powders, particularly when organic solvents are being removed, considerable charges may be generated; but these are usually small compared with the charges generated in handling the dry powder at the end of the process.

It is well known that driving and conveyor belts may generate large electrostatic charges, particularly when the belt is slipping, although the main mechanism of generation of charge is the making and unmaking of intimate contact between the surface of the belt and the pulleys. So favourable are belt drives for the generation of electrostatic charges that Van der Graaf* and his co-workers use the principle in specially designed generators capable of producing 1½ megavolts.

When gases, vapours or liquids are discharged from a jet, they become electrically charged and can communicate the charge to any conductor on which they impinge. The orifice through which the discharge takes place acquires a charge of opposite sign to that of the jet. Wet steam escaping from a faulty joint is a common example of this phenomenon. Faraday's investigations showed that the presence of particles (for example, dust or water droplets) is essential for the formation of the charge. A. W. McDiarmid† claims to have produced charges with jets of uncontaminated dry air, but these conclusions are not universally accepted. A. Breyre‡ has described two ignitions of firedamp in coal mines, due to air flow in a rubber pipe with metal fittings. Hydrogen containing dust particles has a tendency to self-ignition when it escapes through small holes.§ Similar charges may be generated in spray painting; an instance is on record of a potential of 8,000 to 10,000 volts being built up on an insulated metal plate.

Fig. 1.

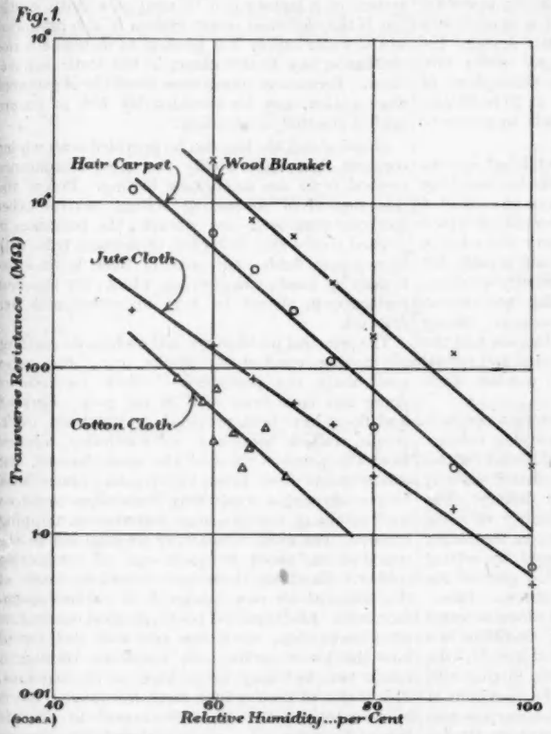
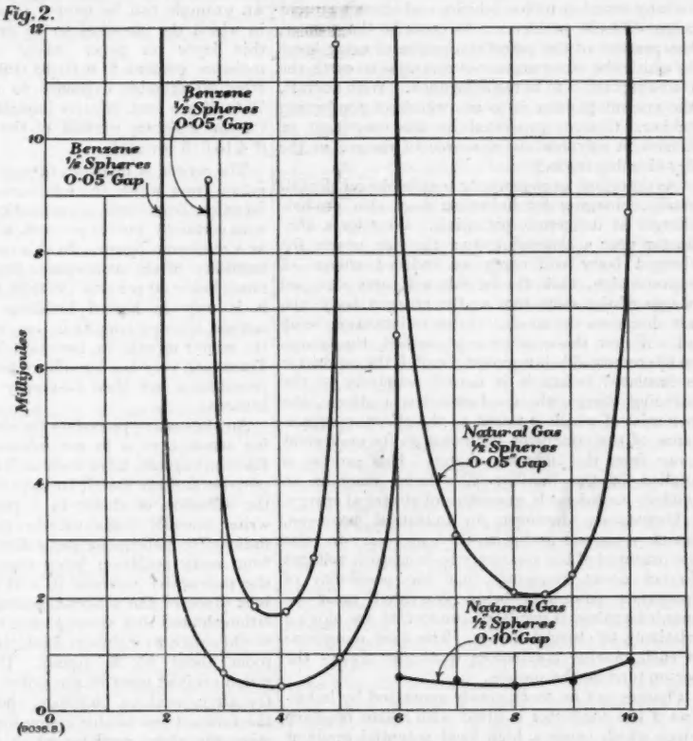


Fig. 2.



* *United States Bureau of Mines, Bulletin* 368 (1933).

† *The Industrial Chemist*, vol. 12, pages 80 and 104 (1936).

‡ G. Morris, *Proc. Phys. Soc.*, vol. 51, page 1010 (1939).

§ P. G. Guest, *loc. cit.*; and U.S. National Fire Protection Association, "Static Electricity," Proceedings of 41st Annual Meeting (1937).

‖ *Phil. Mag.*, vol. 19, page 115 (1935).

¶ *Jl.I.E.E.*, vol. 67, page 1269 (1929).

* *Phys. Rev.*, vol. 38, page 1919 (1931); vol. 42, page 901 (1932); vol. 43, page 149 (1933); and vol. 49, page 761 (1936).

† *Phil. Mag.*, vol. 6, page 1132 (1928).

‡ *Ann. Mines Belgique*, vol. 35, page 44 (1934); and vol. 40, page 86 (1939).

§ Wolton, *Zentralblatt für Gewerbehygiene*, 1924, pages 52, 64 and 86.

Charges may also be generated by the flow of fluids in pipes.* In general, when liquid flows through pipes or tanks, and particularly when the flow is turbulent, there is a tendency for the liquid to acquire a charge of one sign and for the container to acquire a charge of the opposite sign. If the tank is metallic and earthed, the charge on it is immediately dissipated. If the fluid is a semi-conductor, its charge is also dissipated. Most inflammable fluids, however, are fairly good insulators. Such fluid may carry a substantial charge which may raise any insulated metal with which the liquid may come into contact to a dangerously high voltage. It has been found† that the charge increases with fluid velocity and decreases as the pipe diameter increases, and that, while the material of the pipe makes very little difference to the charge generation, roughness of the pipe walls will cause a considerable increase of the generated charge.

The obvious precaution to take in handling inflammable fluids is to connect all tanks and pipes metallically and to ensure that the system is properly earthed. It is essential that the receptacle into which such charged fluids are poured shall also be earthed. This can be done fairly easily with railway cars, but motor vehicles and aircraft present more difficult problems. As regards the former, the practice of the petrol companies of using hoses in which the outer armour is arranged to earth the receiving tank is to be recommended. With aircraft, the present practice is to use wheels of conducting rubber. Charges generated by the movement of fabrics in solvents are a source of danger in the dry-cleaning trade.‡

As described in elementary text-books on electrostatics, charging by induction may also produce charges at dangerous potentials. Consider a conductor near a charged body: the side nearer the charged body will carry an induced charge of opposite sign, while the far side will carry an equal charge of the same sign as the charged body, the net charge on the conductor due to induction being nil. If now the conductor is earthed, the charge on the remote side is removed; and, if the conductor is insulated before it is moved relatively to the inducing charge, the conductor has a charge, the potential of which is raised as the effective capacitance of the conductor decreases on its movement away from the inducing charge. This process is applied in the familiar Wimshurst machine to produce considerable quantities of electrical energy.

Fortunately, however, in industrial processes, the close contact and separation necessary to raise the potential of the conductor to dangerous voltages do not occur frequently, but the possibility of dangerous potentials being generated must be guarded against if insulated conductors are moving relatively to charged bodies. The most dangerous of such moving conductors is almost always the person tending the process.

Charges can be continuously generated by induction if the conductor is fitted with spikes or sharp edges which cause a high local potential gradient and so allow a brush discharge by which the unbound charge can leak away. A familiar example is the collector system of a Wimshurst machine.

Lightning discharges, in addition to the risk of a direct hit, may induce dangerous charges in imperfectly-earthed metallic objects. The subject is too wide for discussion in this article, but it is obvious that, in factories where materials sensitive to spark ignition are handled, special attention should be paid to anti-lightning precautions.

Obviously, the most satisfactory method of countering a static hazard is to change the dangerous material for one in which the ignition energy is so great that the material can be said to be non-explosive or non-inflammable. Examples of this procedure are the use of non-inflammable solvents such as trichlorethylene in dry-cleaning processes, the substitution of chloroform or local anæsthetics for ether, and the introduction of acetate-base cinefilm. Unfortunately, this simple procedure is only of limited application. With gas mixtures, advantage can be taken of the large changes of critical energy associated with changes of composition.

Where a static-generating material has to be handled, and the requirements of the process prevent it from being handled in a conducting condition, (for example, wet powders or solvents containing conducting soap), nothing can be done to prevent the formation of the electric charges; but it is often possible to use working conditions under which the charge can leak away harmlesaly and not collect to constitute a hazard. The most common procedure is to control the atmospheric conditions in the work room so that all surfaces in it are covered with a film of moisture.* As an example of the effect of moisture, some hitherto unpublished measurements, made in the research department of the Explosives Division of Messrs. Imperial Chemical Industries, Limited (with which the author is associated), of the electrical resistance of fabrics stored at various relative humidities are given in Fig. 1, on page 49.

The simplest condition to adopt is to saturate the air by the use of steam or water-spray humidifiers, but care must then be taken that, after handling, the material has not too high a moisture content. An example can be quoted of a drying operation in which the chemical to be dried is spread in a thin layer on paper trays. After drying, the moisture content is 0·01 to 0·04 per cent.; but, after 30 minutes exposure to an atmosphere of 70 to 80 per cent. relative humidity at 25 to 30 deg. C., the moisture content of the bulk increases to 0·4 to 0·5 per cent.

The writer is unaware of any published investigation from which the minimum relative humidity for safety from static accumulation can be estimated with certainty, but 70 per cent. is generally accepted as a minimum figure. In this country, the relative humidity of the atmosphere does not usually fall much below 50 per cent., so that, normally speaking, it is only in heated buildings that precautions against too-dry conditions are necessary. During the winter months in, for example, Canada and the Transvaal, very low humidities are usual and special precautions are then necessary to combat static hazards.

An alternative procedure for obtaining a conducting atmosphere is to use intense ionising sources. Radium capsules have been used in Russia† for this purpose and are stated to have eliminated entirely the adhesion of sheets in a paper factory. The writer recently examined the possibility of using radioactive material for static dissipation, the danger from stray radiation being eliminated by setting the radioactive material in a shielded part of the inlet duct of the air-conditioning system. Calculation showed that about 13 mg. of radium bromide would suffice to maintain conducting conditions in a room about 15 ft. square. Unfortunately, the radon evolved must be prevented from mixing with the air in working buildings, and the provision of the thinnest practicable casing for this purpose also stops the alpha particles which contribute 92 per cent. of the ionising activity of the radium. The capital cost of the radium then becomes prohibitive. Most of the other natural radioactive materials of attractive price and ionising power have too short a half-life to offer a practical solution of the static hazard.

Other sources of atmospheric ions, X-rays and ultraviolet light are not used as static eliminators because the electrical equipment necessary might constitute a far greater risk than the static charges which are to be eliminated. It is understood that gas jets have been used as static eliminators in cotton and paper processing.

It might be thought that the addition of a conducting dust, aluminium powder, graphite or lead dioxide to an explosive powder would improve the rate of dissipation of charges and so lead to increased safety.‡ This is not so, as the introduction of the conducting particles is found to decrease considerably the limiting energy required for ignition. The exact mechanism is not known, but it is thought to be similar to coherer action.

In the majority of cases, however, nothing can be done to neutralise the static charges formed, and an alternative set of precautions needs to be applied. The basic principle is that, since the charge is generated on a body of such good insulation that the charge cannot leak away, it is impossible to obtain an incendiary spark from the charged material itself; and the necessary precaution is to ensure that every conductor from which a spark could be drawn is fitted with an earth connector of adequately low resistance.

Fixed conductors can be connected directly to an earth system, which should be of the type used with lightning conductors, although it is usually unwise to use a common earth for static precautions and for the lightning protection system. Metal plates and rods sunk into moist ground make the best earths. It is convenient to make each earth plate serve a number of conductors against static by the use of local earth mains, which should preferably form closed circuits. The cold-water system of a factory can be used as a static earth, but if the electrical power system is also grounded to the water supply it is prudent to include a series resistance, say 10,000 ohms, in the static connections. Permanent connections should be of generous cross-section, not for conductivity but to ensure against fracture or corrosion.

Shafting and the like can be provided with wiping contacts, but undoubtedly the most satisfactory method is to use conducting belting. Before the introduction of conducting belting, several other methods were used—for example, the provision of pointed combs near belt runs, or dressing belts with hygroscopic fluids—but none of these is so satisfactory as conducting belting, which, for the best performance, should be kept undressed and free from oil.

The principal problem lies in the adequate earthing of moving conductors, trucks, etc., but most particularly the personnel. Various methods of doing this have been used in the past. Earthed lead floors have been provided, on which the workpeople walked barefoot; an admirable solution from the point of view of the static hazard, but unacceptable from other viewpoints. Shoes have been made with a conducting insole connected to a trailing chain, but this may introduce a tripping hazard. The most satisfactory solution lies in the introduction, about 15 years ago, of conducting rubber. Excellent shoes and overshoes made of this material are now marketed by various manufacturers. Leather-soled boots are good conductors when wet; but, when dry and with dirt forced into the lower surface, the resistance through a man's two feet may be as high as 10 megohms. This is not, of itself, a high earth resistance; but it is desirable in case of static hazard to provide special footwear, since many materials sensitive to static may be ignited by other agents—gas mixtures by fusion sparks such as are produced by rubbing grit and steel, and explosives by percussion and friction.

It may be thought that, since wool is an excellent insulator, it will avail little to provide workpeople with special conducting footwear if they wear their own socks. While a dry clean pair of socks has a very high resistance, it is found that, for the average person, the resistance through the sock soles is negligible after 20 to 30 minutes wear. It may be mentioned here that persons of very dry skin constitute an additional hazard in a process in which a static risk occurs. Since they constitute only a small proportion of the population, they should be excluded from such processes.

For the floor surface, lead sheet has the disadvantage that corrosion products have good insulating properties; floors of the magnesium-oxychloride type require to be kept moist if they are to conduct adequately; and the type of floor containing metal grids, very popular some years before the war in the United States, gives rise to uneven wear. The most satisfactory floorings are conducting rubber and conducting asphalt. It is likely that a conducting type of linoleum may soon be available.

* P. G. Guest, *loc. cit.*; and F. B. Silsbee, U.S. National Bureau of Standards, *Circular C.*438 (1942).

† H. Natka, *Chem. Abstr.*, vol. 35, No. 6794 (1941).

‡ Wolton, *loc. cit.*; and L. Hartshorn and W. H. Ward, *Jl. Soc. Chem. Ind.*, T.57, page 178 (1938).

* The natural existence of such an atmosphere for a large part of the year is sometimes cited as the reason for the concentration of the cotton industry in Lancashire.

† *Nature*, vol. 123, page 578 (1929).

‡ Fine aluminium powders as commercially obtained are practically perfect insulators (10^{15} ohm per cm. cube) because of the films of oxide with which the particles are coated.

With the rubber or asphalt floors, all that is necessary to obtain a good earth connection is to lay a metal tape, well bonded to earth, under the edges of the carpet. In testing such a floor, which will usually have a resistance to earth through a man's feet of the order of less than one megohm, many types of test electrode have been suggested, but the simplest and best is to measure the resistance to earth of the hand of a person standing on the floor and wearing conducting shoes. The resistance of the shoes can be separately estimated by tests with the subject standing directly on a metal plate. Since both conducting rubber and conducting asphalt have high temperature coefficients of resistance, to obtain an accurate value of earth resistance the test should be made with the floor at the working temperature of the building.

It must be emphasised that, when a static hazard makes it necessary to take earthing precautions in any plant, such earthing must be thorough. Half measures will probably increase the risk, since it is obvious that, if some conductors are earthed and others left insulated, the opportunities for an incendiary spark discharge may be increased many times.

The charge on an insulated conductor raised to a high potential relative to earth can escape by a direct discharge when a conducting path is formed, the total air gaps in which are not more than the spark length corresponding to the voltage available. A spark so formed is termed a capacitance spark, and is characterised by a rapid rate of discharge unless the ohmic resistances in the discharge circuit are great. It is usually non-oscillatory.

Provided that the potential gradients round the conductor are high enough, the charge may also escape as a corona.* R. W. Sloan† has shown that gas mixtures can be ignited by a corona discharge, but this need hardly be considered in relation to static risks, as the energy required is greater than for a capacitance spark. No prudent plant manager would allow corona discharges on a plant handling spark-sensitive materials.

To evaluate the maximum charge which can be allowed to accumulate in any process without causing a risk of ignition, it is necessary to know the critical energy of capacitance-spark discharge which is necessary to cause ignition. The information available in the literature is summarised below. It cannot be too strongly emphasised, however, that, unless only the order of the critical energy is required, any material which may be involved in a process suspected of having a static hazard should, if possible, be made the subject of a direct experimental study in the exact state, purity, moisture content and temperature in which it is handled on the plant. As with other mechanisms of ignition, the critical firing energy of capacitance sparks, for a given material, decreases with rise of temperature.

Experiment shows that the critical condition for the ignition of a gas mixture is that a critical quantity of energy should be given to the spark. The apparatus required for evaluation of this consists of a stout vessel capable of withstanding the pressures generated by the gas explosion, an apparatus for supplying the required gas mixture, and a condenser, together with an electrical source from which the condenser can be charged to any required voltage. A typical apparatus is that described by P. G. Guest.*

In this paper, Guest describes measurements of the energy necessary to ignite benzene-air and natural gas-air mixtures. His results, which are reproduced in Fig. 2, on page 49, demonstrate the very great effect of gas composition on the required energy; for example, benzene-air mixture, containing 4 per cent. benzene by volume, can be ignited by ½ millijoule, yet the same composition containing 2 per cent. benzene by volume is not fired by 12 millijoules. Guest's experiments also bring out the very considerable influence of experimental conditions, the gas being most easily fired with a long spark gap and with small-diameter electrodes. Similar experiments are described by J. D. Morgan.† Many other investigators have examined gas ignitions, but, since they have been considering the problem in its application to the internal-combustion engine, the electrical system used has generally contained an inductive element. In general, as indicated by Morgan, the energy necessary to cause ignition with an induction spark is of the same order as, but greater than, with a capacitance spark. The composition most sensitive to spark ignition is usually similar to the oxygen balanced mixture and to the composition most sensitive to flame or temperature. Some typical spark energies for ignition are listed in Table I, herewith.

TABLE I.—SPARK ENERGIES FOR IGNITION: SOLVENT VAPOURS.

Vapour.	Concentration by Volume. Per cent.	Capacitance. $\mu\mu$F.	Ignition Energy, Joules.	Reference.
Ether/air	—	$5{\cdot}5 \times 10^5$	about 2·3	M. Riven and A. Sokolik, *Acta Physiochem., U.S.S.R.*, vol. 7, page 823 (1937).
	2·5	$3{\cdot}24 \times 10^3$	0·015	
	5·4	,,	0·0047	R. Viallard, *Comptes Rendus*, vol. 207, page 1405 (1938).
	5·4	1,300	0·0009	
	9·3	$3{\cdot}24 \times 10^3$	0·015	
Alcohol/air	Sat. 15 deg. C.		0·006	
Toluene/air ..	,,		0·005	I.C.I., Limited, Explosives Division Research Department, hitherto unpublished researches.
	,,		<0·4	
Xylol/air	Sat. 21·5 deg. C.		>0·4	
Pentane/air ..		$5{\cdot}5 \times 10^5$	about 2·3	M. Riven and A. Sokolik, *loc. cit.*
Petroleum ether/air		,,	about 2·3	
Benzene/air ..	4 per cent. (most sensitive)		0·0005-0·002	P. G. Guest, U.S. Bureau of Mines, *Report* 3753 (1944).
Pittsburg natural gas.	8 per cent. (most sensitive)		0·0005-0·002	
Methane/air ..	8·8		0·002	J. D. Morgan, *Phil. Mag.*, vol. 45, page 968 (1923).

(*To be continued.*)

STUDY GROUP ON SPECIAL LIBRARIANSHIP.—A study group on special librarianship has been organised by the Association of Special Libraries and Information Bureaux (Aslib), in co-operation with the Library Association, and will be held at Chaucer House, Malet-place, London, W.C.1, from Monday, August 11, to Saturday, August 16. During the mornings, lectures, covering such subjects as foreign bibliographical information and international organisations connected with library work, will be given; in the afternoons, visits will be paid to a number of special libraries, while in the evenings there will be informal lectures on classification systems and bibliographical work. Forms of application to attend may be obtained from "Aslib," 52, Bloomsbury-street, London, W.C.1.

UNIVERSITY OF LIVERPOOL.—Mr. Stanley Dumbell, Registrar of the University of Liverpool, in an article in the *Liverpool Daily Post*, describes the immediate and long-term plans for the expansion of the University. It is hoped to raise the number of full-time students, which is now 2,767, to 3,500 in the next ten years, and arrangements are being made to increase the accommodation, which is already inadequate. A building on Brownlow Hill, the lease of which has been obtained, will be equipped with laboratories for civil engineering, metallurgy, etc., and several other buildings are being obtained for other purposes. The long-term (20 or 30 years) plans include a new building to accommodate the departments of pure and applied mathematics, and a laboratory for the extensive programme of research in nuclear physics, which will be directed by Sir James Chadwick.

THE FUTURE OF PRECAST CONCRETE.

By D. A. STEWART, A.M.I.C.E., A.M.I.E.E.

THE precast-concrete industry has developed along lines similar to those followed by almost every other great industry in the country. This is an evolutionary process induced by a combination of outside stimuli, internal adjustment and rationalisation. The external stimulus is caused by the demand of the public for new products, cheaper products or sub-products which go towards the building of some new service or requirement. The internal reaction comes in the form of improved production, both as to the products themselves and the general efficiency of manufacture. New plant is introduced, better raw materials are obtained, personnel becomes more skilled and hence the standard is raised. All this internal activity has a high percentage of experiment associated with it which is bound to result in the expenditure of money. In highly organised industry this experimenting is called research, and large sums of money are devoted to it. In the smaller and younger industries, it is often unorganised and somewhat "hit or miss," and although results are obtained, these often cannot be fully evaluated through lack of the necessary technical knowledge. In consequence, a promising line may have to be abandoned, or the cost of the new product is found to be so great as to limit its appeal.

The precast-concrete industry may be fairly placed among the young and developing industries, not only in this country but throughout the world; though, naturally, some countries have developed their technique in certain precast processes farther than others. Holland is, perhaps, one of the more advanced in concrete work generally. France has gone a long way in applying vibration as a means of accelerated placing. Germany and America have produced a variety of machines for the manufacture of moulded products. In this country, while thousands of tons of precast products are turned out each week, no outstanding contribution has been made to the technique in regard to the products themselves, or to the machinery connected with their production.

Although a large amount of research has been carried out by technical institutions, universities, commercial and Government laboratories, little advantage is taken of this accumulated knowledge by the industry as a whole. From time to time, specific problems are solved by scientific research and deduction, but, generally speaking, the technique throughout the industry has not emerged from that period of superstition and rule of thumb experienced by all such commercial undertakings in the first years of their evolution. This condition is perpetuated, to some extent, by those who purchase the products of the industry, many insisting on a certain procedure being adopted or a specific type or size of aggregate being used. One wide-spread belief is that granite makes the best concrete, although this is not borne out experimentally; neither is it true that a sharp angular aggregate makes better concrete than a rounded water-worn ballast. The reverse, is, in fact, the case. Water contents, although recognised as having a marked effect on the strength of concretes are seldom really closely controlled. The grading of aggregates and the design of mixes are matters largely left to chance or to individual opinion instead of being based on scientific determinations.

The outcome of all this haphazard procedure is reflected in the low level of performance called for by the British Standard Specifications for most precast concrete products. That the levels are low cannot be denied, but it may be argued with reason that there is nothing in the specification which prevents a manufacturer from producing a product to a much higher standard. This is true enough, but it must be remembered that the main object of manufacturing is to obtain a return on capital, and a return which is as large as possible. If the maximum return can be most easily attained by working to the lowest permissible standard, then there appears to be, on the face of it, no incentive to improve the product.

* *Dielectric Phenomena*, by S. Whitehead. Benn Brothers, Limited, London (1927).

† *Phil. Mag.*, vol. 19, page 998 (1935).

* United States Bureau of Mines, *Report* 3753 (1944).

† *Principles of Ignition*, Sir Isaac Pitman and Sons, Limited, London (1942); and *Phil. Mag.*, vol. 45, page 968 (1923).

This view may hold good so long as a "seller's market" exists, but as soon as the change-over takes place, and the buyer can exercise his normal function of selective purchase, an improvement on the permissible standard will be demanded. The question then arises, need this improvement reduce profits? The answer will depend on three conditions, namely, the kind and value of the improvement; whether or not the demand for the improved product can be increased sufficiently to warrant expenditure on the development of technique and plant; and whether the improved product will engender additional goodwill and thus increase the overall return on capital.

In considering the foregoing and the future of the precast concrete industry generally, serious thought should be given to the critical position which now exists in the labour market, and which is likely to continue for the next 20 years. It is not merely a shortage of man-power, but the cost of this labour that must be faced. The amount of capital which may be justifiably invested to offset an annual labour charge has risen very considerably over the past few years, partly because the money paid out in wages has increased greatly and partly because the rate of interest payable on loans has decreased. Unfortunately, the wage position cuts both ways, forcing up the cost of capital goods by as much as 250 per cent. in some instances, thus making it evident that "cheap money" may not be as cheap as it seemed at first sight. Nevertheless, the labour shortage has to be faced and overcome by one means or another. The most obvious way of dealing with this condition is to eliminate, as far as possible, the dependence of production on man-power by mechanising every process that will release a man or give an existing man an opportunity to augment his output substantially.

In pre-war days, the mechanisation of production raised two problems: firstly, that of meeting the charge on capital and, secondly, the disposal of the greatly increased production—for, unless the production is much increased, the additional overheads that have to be met on account of the new installation, per unit manufactured, might make it unmarketable. At the present time, this disposal problem does not arise, since the demand for all concrete products is far from being met. The time will come, however, within the next few years, when once again pre-war conditions will begin to re-establish themselves; although it is fairly certain that the availability of labour and its cost will prevent a return to the relatively lavish use of man-power which existed in the past.

Mechanised production, if it is to be effective, must reduce handling costs of raw materials and finished products as well as increase the rate of production. This postulates the design and layout of buildings and plant on a carefully planned basis with a view to the through-flow of the production starting with the input of cement, aggregates and reinforcement; and ending with an adequate and balanced discharge system, including mechanical haulage and stacking of the finished product in the stockyards. Here, again, very careful thought must be given to the stockyard layout, and the position and stacking of products in relation to their weight, volume and quantity. It would be a mistake, for instance, to stack kerbs, a quantity production item, close to the source of production, while carrying large-diameter tubes 300 or 400 yards. The kerbs can be hauled ten or a dozen at a time, whereas tubes would require individual handling.

Although steam curing and infra-red curing are used to some extent in the precast industry, these methods of speeding up the setting and hardening of cement will have to be greatly extended if full advantage is to be taken of mechanised production. One advantage derived from accelerated curing is the earlier freeing of moulds so that, on mass production, the mould cost can be restricted to the money expendable on the mould requirements for two to four hours, instead of from 12 to 24 hours, and longer in cold periods. Mould design will also have to be reconsidered—possibly, revolutionised—when not only accelerated curing, but vibration placing and compacting are to be employed. In any case, the present and future position in regard to timber makes it next to impossible to regard this commodity as a suitable material for mould production. Aluminium has proved to be satisfactory as a material, provided that it is suitably alloyed and that the first few casts taken from a new mould are not regarded as indicative of future performance. This is because there is always a certain amount of reaction between the cement and the aluminium during the initial period of use, the degree of chemical action falling off rapidly as a hard oxide skin is formed on the mould surface. Aluminium moulds of considerable size, first put into use in 1937, are still in first-class condition, and of late a large number have been put into service for the production of precast-concrete housing units. At present, experiments are being made on cast Elektron, which, being a magnesium alloy, is about one-third lighter than aluminium. If these tests give satisfactory results, considerable handling costs may be saved in the production of large units and in battery moulding by the use of this lighter alloy, although it is somewhat more expensive than aluminium.

These alloys also have the advantage that they are more easily available than either timber or steel. Both aluminium and Elektron can be welded, but it is a more complicated process than with steel, particularly in the case of Elektron, and consequently the cost is higher. Aluminium alloys possess relatively high tensile strengths and hence are satisfactory for use with high-frequency vibration, even when accelerations of the order of 6 to 8 g are involved. Pressures of 150 lb. per square inch are quite common in deep moulds when concrete is being consolidated at such accelerations, so that the bursting force on a mould of only 6 in. diameter will be 1,800 lb. per square inch for a wall thickness of $\frac{1}{2}$ in.

There is little doubt that the precast-concrete industry has a promising future, provided always that those responsible for its guidance read the writing on the wall correctly and take advantage of the knowledge that is at their disposal. Precast concrete, being factory-produced, can be more easily controlled than other forms of concrete and, therefore, full advantage can be taken of improvements in strength and other qualities resulting from careful grading, batching and mixing. The controlling factor in the strength of any mix is the ratio of water to cement, and this can be far more easily maintained under factory conditions than it can be outside on the site; although it may be mentioned that, at Heathrow Airport, by careful organisation, the concreting of the runways was controlled with great precision, very uniform tests being obtained throughout the contract. Of prime importance in the control of water content is the method and time of storage of the aggregate, particularly the fine aggregate which can carry a very considerable weight of moisture. All storage should be under cover, and the sand should be deposited so as to enable surplus water to drain away. Storage capacity should permit the sand to rest for two days after delivery, if it is supplied from wet pits. Careful sampling should be carried out twice a day, or more often if it is found desirable, to check the value of the water content.

This may seem an unjustifiable expense, but it must be remembered that an increase of 10 per cent. in the water content will reduce the strength of the concrete by as much as 15 per cent. By the exercise of a level of control quite common in many commercial undertakings—for instance, foundries—the possibility of this large variation can be removed, and the extra margin of cement so often added to counterbalance looseness of control may be left out of the mix. If the water content is not allowed to vary appreciably, the cement can be cut down by as much as 10 per cent. without reducing the average ultimate strength of the concrete. An uncontrolled 1-2-4 mix, with cement at 63*s.* per ton, sand at 8*s.*, and stone at 16*s.*, will cost 1*l.* 0*s.* 5*d.* per ton of mix. In a carefully controlled mix, the quantity of cement can be reduced by 10 per cent. and the cost brought down to 19*s.* 9$\frac{3}{4}$*d.* per ton. This saving of 7$\frac{1}{4}$*d.* per ton, on an output of 20,000 tons per annum, represents a reduction in working costs of a little over 600*l.* The bulk of concrete produced by either mix would be the same, since the presence of cement in a mix does not materially change its volume.

While the ratio of cement to aggregate does not in itself affect the strength, the workability of the concrete can be altered greatly by changing the ratios of coarse and fine aggregates in relation to the cement content; where the change tends to stiffen up the mix, more water will be required to re-establish the desired plasticity. If this extra water alters the ratio of water to cement, the strength will be changed; for instance, the presence of excess sand in a mix will require an increase in water content if the concrete is to have the same workability as a mix in which quantities of coarse to fine aggregate are correctly proportioned.

The whole economics of precast concrete depend upon a proper choice of aggregates as regards type and size, and the suitable proportioning of these, together with the cement and water in the mix. By making the right choice and maintaining the relationship, the time of curing may be determined. It is obviously uneconomic to occupy space in a stockyard for three months when, by adjusting the mix suitably, the specified strength of the products can be reached in one month. Quite apart from the small saving in rental, there is the opportunity of turning over the money invested in materials twelve times a year instead of only four times.

The present critical timber position, which is likely to continue for some five to ten years, while it raises a major problem if the old technique of mould making is continued, also offers the industry a new opening in the structural world. It is evident, firstly, that *in situ* work which involves the use of large quantities of timber as shuttering is out of the question; and, consequently, if concrete, as one of the more available materials, is to be used, designs must be altered to make possible the use of factory-produced units. Units of this type can benefit both the designer and the contractor at the site, because, provided a high-quality concrete (that is, one having an ultimate compressive strength exceeding 5,500 lb. per square inch at 14 days) is guaranteed by the precaster, the total weight of material delivered to the contract can be reduced considerably compared with that required for *in situ* work. Furthermore, with factory-produced vibrated units, the required quality of concrete need not be of a mix less than 6 of aggregate to 1 of cement by weight; so that a worth-while saving may be made on the total cement that would have been used otherwise. The production of consistently high-quality concrete requires the closest supervision, and it seems that the time is coming when the precast-concrete industry will have to maintain a staff of trained technicians, and well-equipped test and research laboratories. In this way, and this way only, can this young and virile industry cease to be a backyard occupation and begin to take its place among the established industries of this country.

THE INSTITUTE OF FUEL.—In summarising the 1946 report of the Institute of Fuel, on page 411 of our issue of May 16, we mentioned that an appeal had been launched to raise 25,000*l.* to purchase and redecorate the building in which the Institute is now housed at 18, Devonshire-street, London, W.1. We are informed by the secretary, Mr. R. W. Reynolds-Davies, that more than 13,000*l.* has been contributed to the fund already. It is necessary that the full amount should be obtained by November 11.

L.N.E.R. WAGON AND CARTAGE SHEETS.—The London and North Eastern Railway Company are experimenting with alternative materials for wagon and cartage sheets—commonly called "tarpaulins"—to replace the standard type of flax with linseed-oil dressing, which, although strong, durable, and affording good protection, is very heavy and cumbersome to handle, has a tendency to stiffen or become tacky, involves considerable hand labour, and occupies space for drying for four weeks during manufacture. The Company have evolved nine experimental types of sheets. Four are made of flax (in the loom state), three of flax processed to reduce the weight, one of cotton duck material, and another of nylon. Five separate proofing materials have been applied: linseed oil 90 per cent. and pigment bauxite red 10 per cent.; boiled linseed oil with 3 per cent. carbon black; polyvinyl-chloride emulsion; neoprene; and cupra-ammonium wax. A nylon wagon sheet weighs 39 lb., compared with 70 lb. for the standard sheet, and a cotton-duck cartage sheet weighs 25 lb., compared with 37 lb. for the sheets already in use. The new sheets are also more flexible.

EXHIBITS AT THE ROYAL AGRICULTURAL SHOW.

FIG. 5. "PLOW-MATE" TRACTOR; MESSRS. BRITISH MOTOR BOAT MANUFACTURING CO., LTD.

FIG. 6. "TRUSTY" TRACTOR; MESSRS. TRACTORS (LONDON), LIMITED.

THE ROYAL AGRICULTURAL SHOW AT LINCOLN.

(*Continued from page* 43.)

IT should not be assumed that self-propelled cultivators of the type previously described are limited to light work. That this is not the case is shown by the 6-h.p. "Plow-Mate" light tractor which was exhibited on the stand of Messrs. British Motor Boat Manufacturing Company, Limited, Britannia House, Ampton-street, London, W.C.1, and is illustrated in Fig. 5, on this page. It will be apparent from a study of this illustration, which shows the machine equipped with a single-furrow plough, that it is capable of performing moderately heavy duties. Details of the "Plow-mate" were given in ENGINEERING, vol. 150, page 427 (1940), and it will only be necessary therefore to give brief details here. It is fitted with a single-cylinder, four-cycle, air-cooled petrol engine developing 6 brake horse-power. The transmission is by a sliding gear, automobile-type gearbox to a differential and thence to the wheels through heavy spur gears, the gearbox giving two speeds in the forward direction and one in reverse. The standard tractor is fitted with steel wheels having a diameter of 32 in. and the wheel track is adjustable between the limits of 30 in. and 40 in.; rubber-tyred wheels can be fitted as an alternative. When fitted with steel wheels, the weight of the complete tractor is 748 lb. but for rubber-tyred wheels, this figure is reduced to 738 lb. Since this machine was previously described in ENGINEERING several improvements have been incorporated; for instance, a power take-off is now fitted which can be used for driving a variety of farm machinery within the power output. The range of implements also has been added to, and this now includes a power-operated cutter bar, while another interesting innovation is the introduction of a light trailer so that the machine can be used for the carriage of produce, fertilisers, etc., about the holding.

Messrs. Tractors (London), Limited, Bentley Heath, Barnet, Hertfordshire, also were showing a two-wheeled tractor which is capable of accomplishing, on a reduced scale, most of those duties usually carried out by a four-wheeled tractor. The machine, which is known as the Trusty tractor, is illustrated in Fig. 6, on this page, where it is shown fitted with a power-operated cutter bar. An unusual feature of this machine is the provision of a centrifugal clutch which takes up the drive automatically as the engine revolutions increase. Furthermore, the engine speed is regulated by a twist-grip control incorporated in the right-hand handle bar and this arrangement, together with the centrifugal clutch, makes the machine exceptionally easy to handle. It is powered by a single-cylinder four-stroke air-cooled petrol engine, the engine being located so that the centre line of the crankshaft lies across the tractor frame. The centrifugal clutch is fitted directly to the crankshaft and the drive is transferred from the clutch to a transverse countershaft through sprockets and a roller chain. Each landwheel is fitted to a reduction gearbox consisting of a plain spur gear and pinion and the gearboxes are bolted to the frame of the tractor so that the pinions are located at the top. The pinion shafts are fitted with sprockets at their inner ends, which are connected by roller chains to further sprockets on the engine-driven countershaft. The sprockets on the countershaft, however, are free to rotate about the shaft, the drive being transferred to the sprockets by dog clutches splined to the countershaft and operated by levers fitted to the handlebars of the tractor. It will be realised that, with this arrangement, it is possible to disengage or engage the drive from either, or both, of the landwheels at will, thus giving the tractor a high degree of manœuvrability. The standard tractor is fitted with steel wheels, which can be adjusted for widths of track between the limits of 21 in. and 42 in.; penumatic-tyred wheels are available for use on lawns or similar surfaces, and the tractor illustrated in Fig. 6 is so fitted. Usually, the implements are attached directly to the tractor through a swinging-type drawbar, but by using the trailer shown in the illustration, it is possible to use draught implements; in some cases the implements are attached directly to the frame of the tractor.

A type of tractor that is gaining steadily in popularity, particularly for row-crop work, is the three-wheeled tractor on which the single wheel is mounted in front. This arrangement gives exceptional manœuvrability and allows the tool bar to be mounted either in front of, or beneath, the tractor, thus enabling the driver to see the tools, with consequent greater accuracy of working. A newcomer to this field is the Byron row-crop tractor, illustrated in Fig. 7, on page 54, which was shown on the stand of Messrs. Byron Farm Machinery Limited, College-hill, London, E.C.4. It is powered with a Ford Industrial 10-h.p. petrol engine having a bore and stroke of 2·5 in. and 3·64 in., respectively. The drive is transmitted from the engine through a single dry-plate clutch to a standard Ford three-speed gearbox and then, by a propeller shaft, to an auxiliary gearbox bolted directly to the rear-axle casing. The rear axle is a modified Ford 2-ton commercial type fitted with a spiral-bevel final drive and bevel-pinion type differential. The rear wheels are equipped with internal-expanding brakes arranged to operate either independently or together, thus enabling the tractor to turn in a circle of small radius. The single front wheel is fitted with a 4-in. by 15-in. pneumatic tyre and the rear wheels with 8-in. by 24-in. pneumatic tyres, the track of the rear wheels being adjustable between the limits of 56 in. and 73 in. Obviously, the tractor is not confined to row-crop work; it is quite suitable for ploughing, harrowing, etc., and light haulage work, and in this connection the maximum drawbar pulls for the various gear ratios, which are 1,400 lb. in first gear, 1,200 lb. in second gear, and 900 lb. in top gear, may be noted.

A three-wheeled tractor of somewhat different layout was exhibited on the stand of Messrs. Kenneth Hudson and Son, Elland, Yorkshire. This tractor is illustrated in Fig. 8, on page 54, and it

will be noted that in this case the engine is mounted behind the driver while the tools are fitted to a toolbar carried in a central position underneath the frame, an arrangement which provides an exceptionally clear view of the implements while at work. The toolbar is raised and lowered by a hydraulic-lifting mechanism, and it will be noted that the track eliminator is coupled into the hydraulic lift system so that it works in conjunction with the toolbar. The tractor is powered by a four-cylinder water-cooled petrol engine, which develops 17 brake horse-power at 2,000 r.p.m., the bore and stroke being 2·5 in. and 3·64 in., respectively. Coil ignition is employed and, as a consequence, the engine is fitted with a 6-volt dynamo arranged to charge a 6-volt battery; a 6-volt starter motor is also fitted. The drive from the engine is transmitted through a single dry-plate clutch to a gearbox, which provides three forward speeds and a reverse, the gearbox being fitted with helical, constant-mesh gear wheels for second and top speeds, and plain spur gears for first and reverse. The final drive to the differential is through chains and the chain case is visible in Fig. 8, where it can be seen just behind the toolbar. The single front wheel is fitted with a 5-in. by 15-in. pneumatic tyre and the rear wheels with 7-in. by 24-in. low-pressure tyres, the rear wheels being fitted to offset lugs so as to provide for track adjustment. The rear wheels are fitted with brakes arranged so that they can be applied either individually or together. The total weight of the tractor when fitted with the toolbar, nine cultivating tines, and the track eliminator is in the neighbourhood of 30 cwt., while the overall length, width and height when so equipped are approximately 9 ft. 10 in., 6 ft. 9 in. and 6 ft. 6 in., respectively. It is interesting to note that the toolbar is fitted with pneumatic-tyred depth-control wheels, which are clearly visible in the illustration. The tractor can be used for many duties other than cultivation, and the range of tools and attachments available includes those for potato lifting, beet lifting, seed drilling and ploughing.

Probably the most familiar of all farming machinery is the four-wheeled type of tractor, which, in the course of time has been adapted to perform an ever-widening variety of operations. Perhaps the most notable development in tractor farming is the introduction of mounted implements wherein the implements and the tractor work together as an integral unit, the implements being raised clear from the ground or lowered to the working position by a hydraulic-lifting gear fitted to the rear of the tractor. This system was pioneered largely by Mr. Harry Ferguson and the firm of Messrs. Harry Ferguson, Incorporated, founded in the United States in 1939, has become one of the leading manufacturers of mechanised agricultural equipment. Until recent times this firm confined its manufacturing activities to the Western hemisphere, but last year a British counterpart, Messrs. Harry Ferguson, Limited, Coventry, was formed to set up in this country an organisation similar to that operating in the United States. The tractor is being manufactured by the Standard Motor Company, Limited, at their Banner-lane factory, Coventry, while the farming implements are being manufactured by a number of firms situated in different parts of the United Kingdom. This was the first time, therefore, that Messrs. Harry Ferguson, Limited, had exhibited at the Royal Show, and their exhibits included two- and three-furrow ploughs, a three-row ridger, and a spike-tooth harrow, all operated from the hydraulic lift and link assembly. The hydraulic system on the Ferguson tractor, however, has been carried a stage farther, in that it is designed to keep the plough, or other implement, at a constant depth; furthermore, the linkage is arranged so that striking an obstacle causes the load to be removed from the tractor rear wheels, thus preventing damage to both the implement and the tractor, and, at the same time, ensuring that the front wheels remain on the ground—a valuable safety factor. Perhaps the most important feature is the fact that the load on the plough share is used to hold the tractor to the ground, an arrangement which increases the adhesion without the use of weights. An illustrated description of both the tractor and its hydraulic system will be found in ENGINEERING, vol. 163, page 151 (1947). Of the exhibits already mentioned, the spike-tooth harrow is perhaps the most interesting, as this is arranged in three sections, the two outer sections being designed to fold against each other in order to simplify transport; this results in a harrow of exceptional width. Another interesting exhibit on Messrs. Ferguson's stand was a circular-saw bench attached to the rear of the tractor through the three-point linkage and driven from the rear power take-off. The complete saw bench is arranged so that when it is required in a fresh location, it folds back on to the rear of the tractor.

Another firm which has made a close study of tractor farming is the Ford Motor Company, Limited, Dagenham, and their exhibits also included a wide range of tractor-mounted implements for use in conjunction with their hydraulic-lift assembly. The Ford lift, however, does not control the depth of the implements, this function being performed by land wheels fitted to the implements, the wheels being adjustable for height. Messrs. Ford have always believed in working in close co-operation with the various implement manufacturers, and one of the implements shown was a three-furrow mounted plough manufactured by Messrs. Ransomes, Sims and Jefferies, Limited, Ipswich, for use with the Fordson Major tractor; the former, was described in detail in ENGINEERING, vol. 162, page 536 (1946). Since this plough was described, several other implements have been designed for use with the Fordson Major, and one of the most interesting shown was a mid-mounted tool bar, manufactured by Messrs. Martin's Cultivator Company, Limited, Stamford; this is illustrated in Fig. 9, on page 60. The tool bar is suspended by links from a sub-frame bolted to the tractor and the links are connected to the hydraulic-lift

EXHIBITS AT THE ROYAL AGRICULTURAL SHOW.

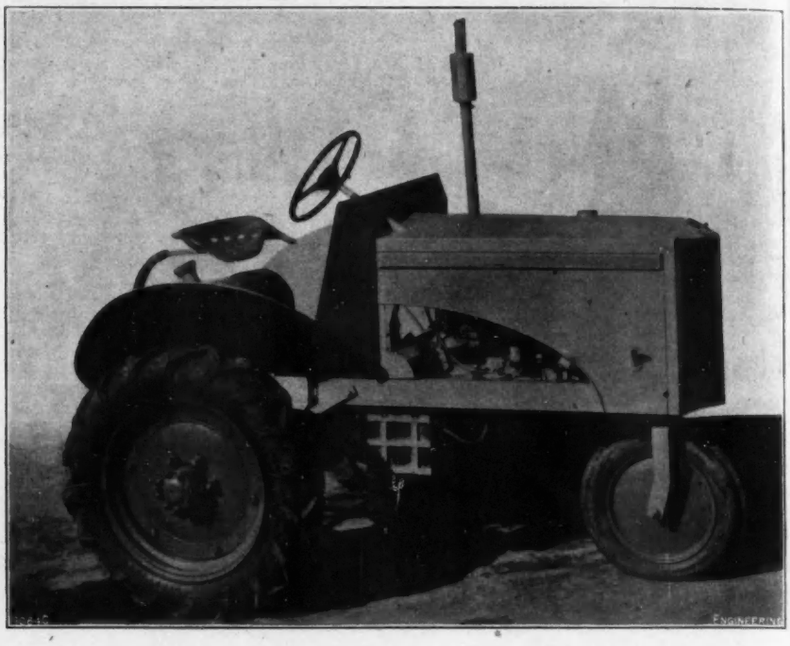


FIG. 7. ROW-CROP TRACTOR; MESSRS. BYBON FARM MACHINERY LIMITED.

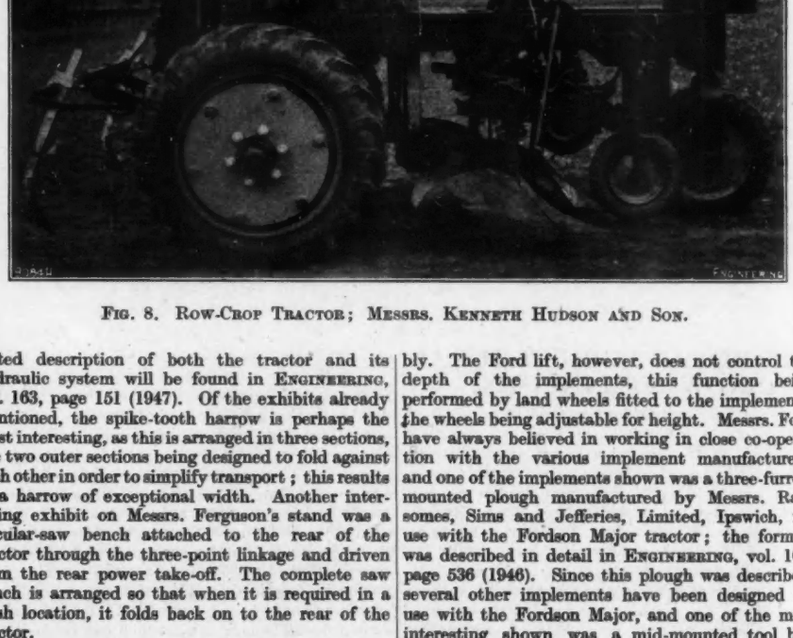


FIG. 8. ROW-CROP TRACTOR; MESSRS. KENNETH HUDSON AND SON.

mechanism, thus enabling the tools to be brought either into, or out of, operation at will. It will be noted from the illustration that a rear tool bar also is fitted and this is arranged to be raised or lowered in conjunction with the mid-mounted tool bar. The main advantage gained by fitting the tools in this position is, of course, that they are always in full view of the driver. The tools are kept at a constant depth by two small land wheels, which are adjustable for height and which follow the contours of the ground. Another interesting exhibit on this stand was a 5-ton winch, which can be fitted to a Fordson-Major tractor and retained in position without interfering with the tractor's general work on the farm. The winch is manufactured by Messrs. Darlington Engineering Company (Gateshead), Limited, Gateshead-on-Tyne, and it is shown in position in Fig. 10, on page 60. It is driven from the rear power take-off and the reduction gearing consists of a worm and wheel which run in an enclosed oil bath. It will be seen from the illustration that the winch is fitted with guide rollers, a towing bracket, a towing plate for ploughing, and a sprag.

Messrs. David Brown Tractors, Limited, Meltham, Yorkshire, were exhibiting their new four-wheeled tractor, the Cropmaster. In its main essentials, the Cropmaster is similar to the earlier VAK.1A tractors which have been described from time to time in ENGINEERING, but several improvements have been incorporated which enhance its usefulness considerably. For instance, the final drive has been redesigned, the gear ratio having been increased and the gears strengthened, thus reducing the speed but providing a greater torque at the rear axle. In order to make full use of the increase in torque, the weight distribution has been altered, the result being an increase in the drawbar pull of some 10 per cent. on that obtained formerly. Several modifications have been made also to the power lift and link assembly. The hydraulic system is now situated in front of the gearbox and uses the oil within the gearbox, the oil being fed under pressure to a ram cylinder fitted to the near-side of the rear axle. The working pressure has been reduced from 1,300 lb. per square inch to 600 lb. per square inch but the general design has been altered to give a gain in the upward lift at the end of the link arms of approximately 90 lb. The linkage generally has been strengthened and several refinements made in the design. The power lift can now be locked in either the raised or lowered position, while a half-way position is provided for direct-attached implements the depths of which are controlled from the tractor. The geometry of the linkage also has been altered, in that the tractor-end of the top link is now fitted to a bracket on the ramshaft which rotates with the shaft, thus ensuring that the pitch of the implement remains constant, regardless of the depth of working. The improved linkage is illustrated in Fig. 11, on page 60, and the methods of adjusting the lengths of the three links will be apparent from a study of this illustration.

The four-wheeled tractors so far mentioned are all fitted with comparatively high-speed, multi-cylinder, petrol or petrol-paraffin engines and a tractor in marked contrast with these was shown on the stand of Messrs. Marshall, Sons and Company, Limited, Gainsborough, Lincolnshire, who were exhibiting their Field-Marshall Mark I Series 2 Diesel-engined tractor. Basically, this tractor is similar to its predecessor, which was described in detail in ENGINEERING, vol. 141, page 707 (1936), but several improvements have been introduced in the latest model, which is illustrated in Fig. 12, on page 60. The power output from the single-cylinder valveless two-stroke Diesel engine has been increased to 38-40 brake horse-power without increasing the speed, which remains at 750 r.p.m. In order to transmit the increased power, a larger clutch with a modified cone angle has been fitted and improved materials used for the gear wheels. The most notable improvement, however, is in the braking system, as the transmission brake referred to in our previous description has been replaced by internal-expanding brakes which operate on both rear wheels, either together or independently.

(To be continued.)

INTERNATIONAL ELECTRICAL AND PHOTOMETRIC UNITS.

IT is officially announced by the Director, Sir Charles Darwin, K.C.B., F.R.S., that in accordance with decisions taken by the International Committee of Weights and Measures at their meeting in Paris in October, 1946, the system of electrical units employed at the National Physical Laboratory will be changed on January 1, 1948. The units at present in use are the "international" units, which are based on certain material standards. From January 1, 1948, the units employed will be those derived from the centimetre, gramme and second, i.e., the so-called "absolute" units. The effects of this change may be seen from the following table:—

One international ohm	= 1·00049 "absolute" ohms.
One international volt	= 1·00034 "absolute" volts.
One international ampere	= 0·99985 "absolute" ampere.
One international watt	= 1·00019 "absolute" watts.
One international henry	= 1·00049 "absolute" henries.
One international farad	= 0·99951 "absolute" farad.

The factors given in this table apply to the mean international units; that is to say, to the mean values of the international units as realised at the various national laboratories.

After January 1, 1948, apparatus submitted to the Laboratory with a view to the issue of a National Physical Laboratory Certificate of Examination will be regarded as acceptable if its errors fall within the specified limits when the values are expressed in either international or absolute units, provided that it was manufactured before January 1, 1949, and is marked accordingly. Apparatus manufactured after January 1, 1949, and any apparatus not marked with the date of manufacture, will be acceptable only if its errors fall within the specified limits when the values are expressed in absolute units.

As a result of a second decision of the International Committee of Weights and Measures, the National Physical Laboratory will also, on and after January 1, 1948, express all photometric values in terms of units based on the "new candle." This unit of luminous intensity is of such a magnitude that the brightness of a full (or cavity) radiator (black body) at the temperature of solidification of platinum is 60 new candles per square centimetre. The new lumen is the luminous flux radiated within unit solid angle by a uniform source having a luminous intensity of one new candle. The new unit of illumination will be one new lumen per unit area. One new lumen per square foot will also be called one new foot-candle, and one new lumen per square metre one new lux. The new unit of brightness will be one new candle per unit area, and, alternatively, one new foot-lambert. The latter unit is defined as the brightness of a perfectly diffusing surface of 100 per cent. reflection factor when its illumination is one new lumen per square foot.

When differences of colour are involved in the determination of any magnitude in terms of the above units, the evaluation will be in accordance with that which would be obtained by an observer having the relative luminosity curve (curve connecting eye sensitivity with wavelength) adopted by the International Commission on Illumination in 1924, and later by the International Committee of Weights and Measures.

It is pointed out that the differences between the new units and those in use hitherto are small. The present units, based on the "international candle," were introduced on April 1, 1909, in Great Britain, France and the United States of America, and were adopted in 1921 by the International Commission on Illumination. Nevertheless, Germany and some Central European countries continued to use units based on the Hefner candle (about 0·9 international candle). The international candle was not based on any primary standard; it was derived from the units defined in terms of the old flame standards and was maintained by means of carbon- and tungsten-filament electric lamps. Further, the values of the unit at different colour temperatures did not agree exactly, when compared on the basis of the international relative luminosity curve adopted in 1924.

The magnitude of the new unit has been chosen so that it will introduce only very small changes (less than 0·5 per cent.) in the values of luminous intensity assigned to lamps operating at a colour temperature of about 2,360 deg. K. For lamps at considerably higher colour temperatures, *e.g.*, ordinary gas-filled electric lamps at normal efficiencies, the values expressed in terms of the new candle will be several per cent. lower than those expressed in international candles. At the colour temperature of the primary standard (2,046 deg. K.), values in terms of the new candle are about 1·7 per cent. higher than those in terms of the international candle. On account of this alteration in the basis on which sources of light of different colours are compared, it is impossible to give a factor for converting values in international candles to values in new candles.

LINEAR DIVIDING ENGINE.

IN order to meet their own requirements, Messrs. E. R. Watts and Son, Limited, Camberwell-road, London, S.E.5, have always designed and manufactured the circular dividing engines used in their works for cutting the scales fitted to their theodolites and other instruments. The first of these engines was built by Messrs. Watts in 1904 and has been in constant use since that date. In more recent years, the firm have entered the field of linear measurement, for which purpose they designed and constructed a range of precision linear dividing engines for the graduation of precision scales for jig-boring machines, line standards for the metrologist, and standard yards and metres, both for the engineer and for physical laboratories. In view of the successful application of these engines to their own products, Messrs. Watts decided recently to market a range of both circular and linear machines designed to have a wide field of application, and one of these, a 40-in. linear dividing engine, is illustrated on pages 56 and 57. Basically, the engine depends on an accurately machined lead-screw which advances a table on which the scale to be divided is clamped, the advancing mechanism being arranged to operate intermittently, so that the scale can be marked during the dwell.

A general view of the engine is given in Fig. 1, on page 56; it consists of a sturdy bed, of box form construction, which is supported at three points only in order to reduce distortion to a minimum. The lead-screw is in two plain bearings, one at each end, located towards the top of the bed as nearly as practicable to the plane of the work, and its length is approximately half that of the bed. A circular nut is threaded over the lead-screw and one end of a moving table is kept in contact with the nut by a system of weights and cords. The table moves along the bed on four ball-bearing rollers with vertical axes, while underneath the table are two fixed rollers with horizontal axes, and two pivoted and sprung rollers. The two fixed rollers are on one side of the table while the two sprung rollers are on the opposite side, and these rollers, by contacting the inner vertical surfaces of the main bed, ensure free but accurate longitudinal movement of the table. The bed also carries the ratchet mechanism for transmitting the intermittent rotary motion to the lead-screw, the driving pulley bracket, and the supporting bracket for the marking mechanism, known as the tracelet.

The ratchet mechanism for transmitting intermittent rotary motion to the lead-screw is shown in the photograph reproduced in Fig. 2, on page 56, and diagrammatically in Figs. 3 and 4, on the same page, which will serve to illustrate its method of working. The shaft *a* is driven by an electric motor and V-belts, as shown in Fig. 2, and fitted to the end of this shaft is the crank arm *b*. The arm *b* carries the crankpin *c*, the inner end of which is free to slide within a longitudinal slot formed in the arm. Its position along the arm, however, is determined by the threaded rod *d*, which passes through a tapped hole machined in that portion of the crankpin located within the slot; by rotating the threaded rod, the crankpin can be moved either away from or towards the shaft *a*, thus making it possible to adjust the throw of the crankpin within fine limits. Fitted to the crankpin *c* is one end of the connecting rod *e*, the other end of which is fitted to a journal on the sector *f*, the sector being free to reciprocate about the shaft *g* which is clamped to the bed of the engine. The sector *f* has a rack formed in its periphery which meshes with the gear wheel *h*, Fig. 3, and, in order that the rack and gear wheel may be in close mesh and free from any backlash, the shaft *g* is eccentric, and the flange is rotated to bring the gears into perfect mesh before the fixing holes are drilled in the bed of the machine. The holes in the flange are enlarged so as to permit a further adjustment during the life of the machine. The gear wheels *h* and *i* are integral, and the latter meshes with the gear wheel *j*, which is free to rotate about the end of the lead-screw *k*, the wheel *i* being split, or laminated, in order to eliminate backlash between *i* and *j*. The disc *l* is integral with the gear wheel *j*, and fitted to the disc *l* is the pawl *m* which engages with the teeth of a ratchet wheel *n*, keyed to the end of the lead-screw *k*. It will be seen that when the arm *b* rotates, the connecting rod *e* will cause the sector *f* to reciprocate about its shaft, and this motion will be transferred to the disc *l* by the gear train *h*, *i* and *j*. When the disc rotates in a clockwise direction, as viewed in Fig. 4, the pawl will idle over the ratchet wheel *n*, but when the disc rotates in an anti-clockwise direction, the pawl will engage with the teeth of the ratchet wheel and rotate it, together with the lead-screw, an amount determined by the throw of the crankpin *c* which, as previously explained, is adjustable. The lead-screw nut is restrained from turning with the lead-screw, so that rotation of the lead-screw causes the nut, and therefore the table, to be displaced in an axial direction. The actual movement of the table for each revolution of the arm *b* depends, of course, on the position of the crankpin

c, and the movement of the table for the various positions of the crankpin is shown on a scale fitted to the arm b. The movement of the lead-screw can be checked by reference to the circular scale o, which is integral with the ratchet wheel n, and the fixed vernier p.

Obviously, the performance of the engine is governed largely by the precision of the lead-screw and any pitch errors, however small, which may be present in the lead screw after machining are corrected by advancing or retarding the movement of the lead-screw nut, according to whether the pitch error is negative or positive. The method by which this is accomplished is illustrated in Figs. 7 and 8, opposite. Fig. 8 is a plan view of the table f, the lead-screw r, and the nut t, while Fig. 7 is an elevation of the nut and table when viewed in the direction A A indicated in Fig. 8. It will be seen that an arm a extends from one side of the nut and that the arm is fitted with a roller b, which is held in contact with the bar c, known as the error-correction bar, by the action of the spring d, Fig. 7; the lower end of this spring is fitted to the arm e, which extends from the table f. The correction bar is fitted to the frame of the engine, and it will be realised that any alteration to the contour of this bar will cause the roller either to rise or fall as the table is moved along, and thus advance or retard the linear movement of the nut. When the machine has been assembled, therefore, the advance of the table is checked against a master scale and any errors are corrected by altering the contour of the correction bar.

Should the lead-screw not be truly axial, the face of the nut against which the table bears will not be exactly at right angles to the longitudinal axis of the table, and this also will have an adverse effect on the accuracy of the engine. This possibility is overcome by interposing a gimbal plate between the nut and the table, and this plate is shown at g in Fig. 8, from which it will be seen that it is held in position over the balls h by the action of the springs j. The table, however, is not connected directly to the gimbal plate g, but rests against two vertical pads fitted to the face of the plate, one of which is shown at k in Fig. 8; the table is held thereto by the action of the cords and weights referred to previously.

In order to compensate for variations in ambient temperature and to permit the engraving of scales on materials having coefficients of expansion different from that of the lead-screw, it is necessary to arrange for the table to advance either a greater or smaller amount than that which would be transmitted by the lead-screw. This is accomplished in a manner similar to that employed for pitch-error correction, and the mechanism is shown diagrammatically in Figs. 7 and 8. It will be seen from Fig. 8 that a spigot projects from that end of the table in contact with the pads of the gimbal plate. This spigot is machined with a fine thread over which is threaded the nut l, and it will be realised that if this nut is unscrewed progressively while the table advances, the distance x between the face of the nut and the edge of the table will increase, and consequently, the table will be given motion in excess of that imparted by the lead-screw. Conversely, if the nut l is screwed up while the table advances, the distance x will decrease and the movement of the table will be less than that imparted by the lead-screw. It will be seen from Figs. 7 and 8 that the nut is fitted with an arm m, the free end of which is fitted with a roller n, and the roller is held against the bar o, known as the temperature-compensation bar, by the action of the spring p. The bar o is located along the front, and towards the top, of the engine bed, and can be seen in Fig. 1 in front of the table. That end of the bar towards the middle of the engine is pivoted to the frame, whereas the other end is secured to the frame by a clamp screw which passes through a vertical slot formed in the end of the bar, thus allowing the bar to be given an incline upwards or downwards in relation to the horizontal. If the incline is downwards towards the centre of the engine, the roller n, and its arm m, will fall as the table moves to the right, thus imparting clockwise motion to the nut l and causing the distance x to be reduced. Conversely, lowering the end of the bar will have the opposite effect and the distance x will be increased as the table moves to the right. It is obvious that when the top of the bar is parallel to the surface of the main bed, no extra motion is imparted to the nut l and the movement of the table is dependent on the lead-screw only. A graduated scale is fitted to the side of the vertical slot of the temperature-correction bar, one division of which is equal to the ratio of two in a million.

The tracelet mechanism is carried on a substantial bracket bolted to the side of the engine frame. It is driven by an extension of the driving shaft for the table-advance mechanism, and this shaft, together with the bracket and tracelet mechanism, can be seen in Fig. 2, on this page. The tracelet mechanism is shown in greater detail in Figs. 5 and 6, opposite, and, diagrammatically, in Fig. 9. The driving shaft is led through the tracelet supporting bracket into a cam box cast integrally with the base of the bracket. The cams

LINEAR DIVIDING ENGINE.

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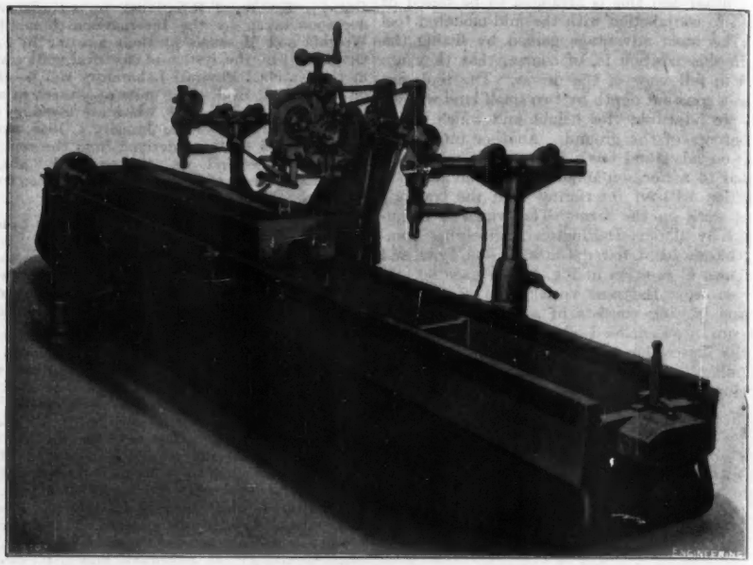


FIG. 1.

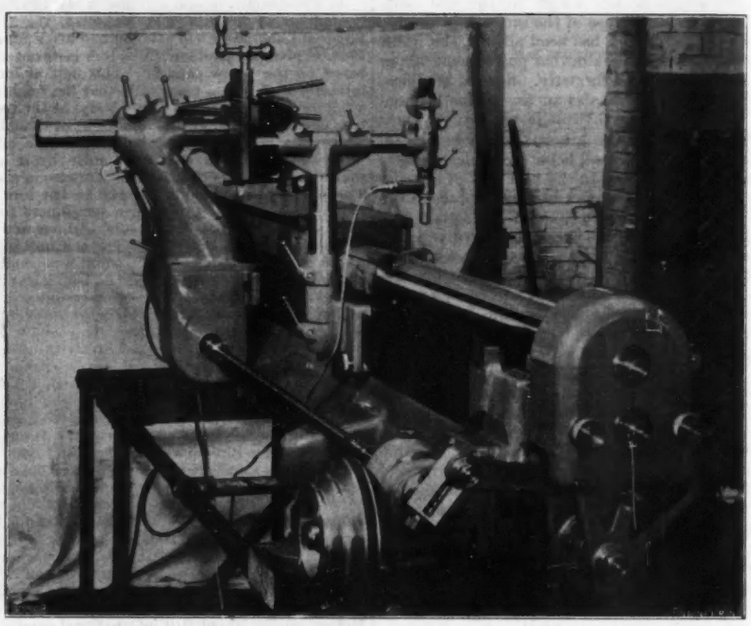


FIG. 2.

Fig. 3.

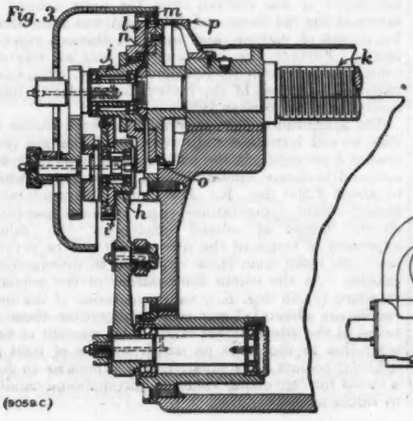
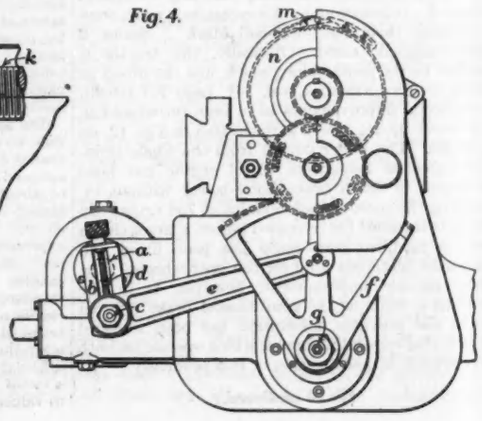


Fig. 4.



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LINEAR DIVIDING ENGINE.

MESSRS. E. R. WATTS AND SON, LIMITED, LONDON.

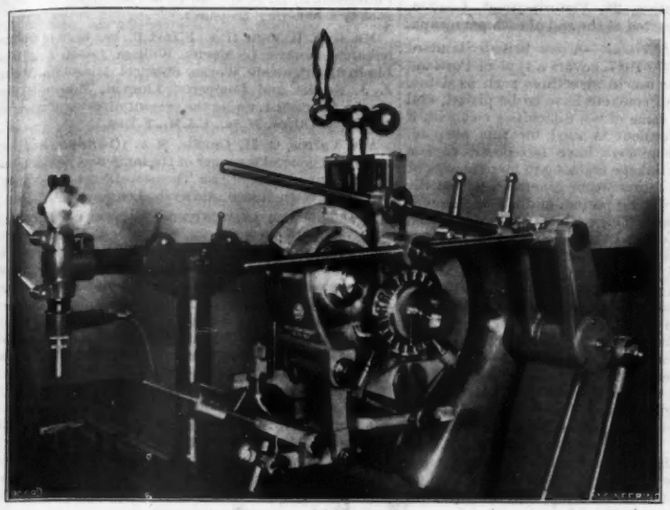


FIG. 5.

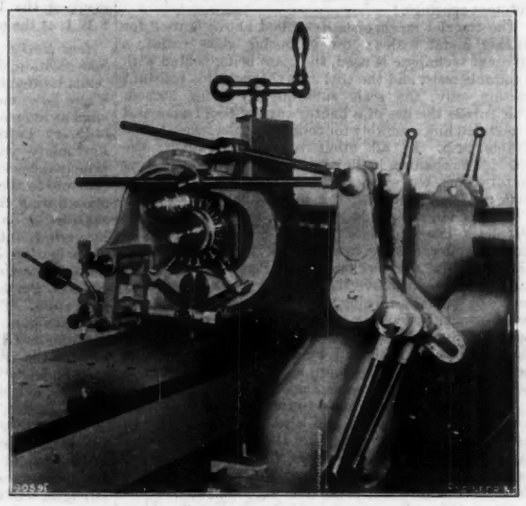


FIG. 6.

Fig.7. ELEVATION AA (Fig.8.)

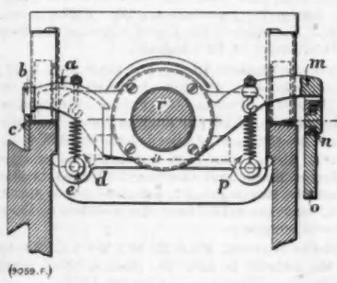


Fig.8.

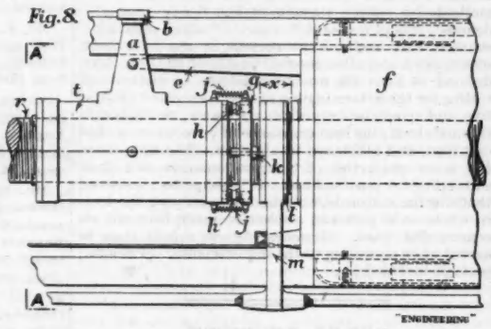
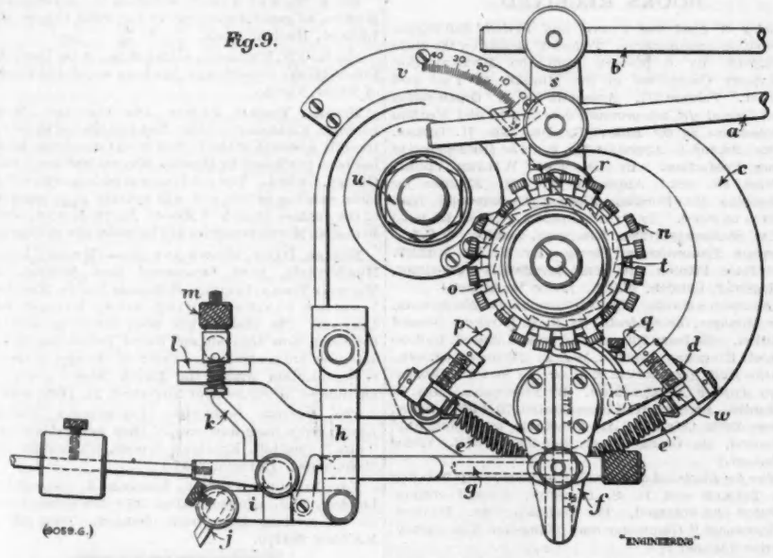


Fig.9.



operate two vertical push rods located by guides in the top of the cam box, and the upper ends of the push rods are connected to two variable-throw bell-cranks, which can be seen in Fig. 6. The bell-crank farthest from the bracket operates the rod marked *a* in Fig. 9, while the other bell-crank operates the rod marked *b* in the same figure.

It will be seen from Fig. 9 that the rod *a* is connected to the arm *c*, which is arranged to pivot about its lower end. The double arm *d* is pivoted about the same axis as the arm *c* and is connected thereto by the springs *e*. Attached to the double arm *d* is a further arm *f*, and this arm is connected through the link *g* to the stirrup *h*. The top of the stirrup is pivoted to the frame of the tracelet mechanism and is thus free to swing in the vertical plane; it carries, at its lower end, the frame *i*, which, in turn, holds the cutting tool *j*. The frame *i* is pivoted to the stirrup *h* and is held in the horizontal position by the rod *k*, which is integral with the frame *i* but is fitted at its top end with a roller which rests upon the arm *l*. The position of the roller relative to the rod *k*, however, is adjustable, thus making it possible to vary the effective length of the rod *k* and, therefore, the height of the cutting tool relative to the table. It will be seen that when the outer bell-crank is caused to reciprocate by the action of the cam and push rod, previously referred to, the motion will be transmitted to the arm *c* by the rod *a*, and thence, through the springs *e*, to the double arm *d*. The arm *f*, however, is integral with the double arm *d* and the reciprocating motion, therefore, will be transmitted by this arm and the link *g* to the stirrup *h*, and the cutting tool, in consequence, will be moved backwards and forwards. The actual cutting operation occurs as the tool is pulled to the right, or towards the rear of the machine, and it is raised from the work during the return stroke by the arm *l* which, in turn, is raised and lowered by a cam operated by the arm *c*.

The stroke of the cutting tool is regulated by altering the effective length of the arm *f*, which is slotted, and the small pin which connects the link *g* to this arm can be locked at any desired position along the slot. Altering the effective length of the arm *f*, however, serves only as an approximate setting for the length of line cut by the tool *j*; this is governed finally by the plain disc *o* and stop pegs *n*. Each end of the double arm *d* is fitted with an adjustable tappet; the tappets, however, are not in the same vertical plane but are offset to each other so that when the arm *d* swings in a clockwise direction, the tappet *p* contacts the plain disc *o* and when the arm swings in anti-clockwise direction, the tappet *q* contacts one of the stop pegs *n*, located immediately to the front of the plain disc *o*. Owing to the limiting action imposed by the plain disc *o* and the tappet *p*, the cutting tool must return to exactly the same position before starting the next cut; the excess movement of the arm *c* over the double arm *d* is absorbed by the springs *e*. Both the plain and stop discs, however, are rotated a distance equal to that between two pegs during each return stroke of the cutter, thus bringing a different peg opposite the tappet *q* for each cutting stroke. Thus, by fitting pegs of various heights, it is possible to vary the length of line engraved by the cutter during successive cuts. Here again, the excess movement of the arm *c* over the double arm *d* is absorbed by the springs *e*; obviously, when setting the tool, the stroke of the tool as limited by the length of arm *f* must exceed that imposed by the disc *o* and pegs *n*. These are rotated by the pawl *r* which is fixed to the arm *s* and engages with the ratchet wheel *t*. The arm *s* is actuated by the rod *b* which, as previously mentioned, is reciprocated by the inner bell-crank lever.

The disc *o* and the disc into which the stop pegs *n* are screwed are interchangeable, and when in the position shown in Fig. 9, the variations in the lengths of the engraved lines will be towards the rear of the machine. If the pegs *n* are placed behind the plain disc *o*, the length variations will be towards the front of the engine. On the other hand, if two plain discs are fitted, all the engraved lines will be equal in length, while if two stop discs are fitted, the length variations

will be both towards the front and back of the engine. Furthermore, by changing the ratchet wheel f and by using stop discs with a corresponding number of pegs it is possible to vary the sequence of the length variations as required, and stop discs provided with each engine permit the engraving of a wide range of different spacings.

The tracelet mechanism described above is used for cutting metal scales; for producing glass scales, a different technique is used, the glass being coated with a suitable resist and the tool cuts through this resistant coating only, the scale subsequently being etched. This entails the use of a lighter cutting-tool frame and a modified link assembly for connecting the frame to the double arm. In all other respects, however, the tracelet mechanism is the same as that used for cutting metal scales, but whereas the maximum length of line that can be ruled with the metal-cutting tracelet is 1 in., this length is reduced to $\frac{1}{2}$ in. for the glass-ruling tracelet. The complete tracelet mechanism can be raised or lowered by operation of the crank handle visible above the mechanism in Figs. 5 and 6, the maximum height above the table to which the cutting tool can be raised being $2\frac{1}{2}$ in. Bevelled scales are ruled or cut, by loosening the nut lettered u, in Fig. 9, and swinging the tracelet through the angle of the bevel, the angle being indicated by the scale v. It also is necessary to loosen the clamp w, so that the arm c can be moved through the same angle.

Two microscopes are fitted to the frame of the engine for checking calibration and also to enable it to be used as a comparator; they are also useful for examining the various types of ruling. The microscopes are carried in adjustable brackets, the bases of which slide over a dovetail formed along the back of the engine; this arrangement is visible in Fig. 2. They can be fitted either with external illumination for the examination of metal scales or with internal illumination for use with glass or highly polished scales.

The engine can be supplied either with an English lead-screw having 10 threads per inch or a metric lead-screw with a pitch of 2 mm. An engine fitted with a metric lead-screw can produce all the usual divisions in English units and vice versa, by the use of a ratchet wheel with 127 teeth, although there is some restriction on the metric machine in cutting all types of English verniers. The English machine, however, does not suffer any restriction in cutting the usual metric verniers; it would appear, therefore, to be the most advantageous. The ratchet wheel fitted to the end of the lead-screw is interchangeable with others having a different number of teeth, as has been indicated, and a range of wheels is supplied with each engine. Logarithmic and other scales with irregular spacings can be produced, but in such cases the engine has to be operated by hand, for which purpose a crank handle is supplied. The crank handle is used also when setting up the engine and for returning the table to its starting position after each scale has been cut. The handle fits over the spigot formed at the end of the shaft which carries the intermediate driving pinions. The capacity of the engine is 40 in., the width of the table being $8\frac{1}{2}$ in. The overall dimensions are: length 8 ft. 9 in., width 2 ft. 4 in., and height 2 ft. 9 in. The driving motor usually supplied is of $\frac{1}{4}$ h.p., for 400 volt three-phase current, but different motors can, of course, be supplied.

POWER STATION CONSTRUCTION.—The Ministry of Works state that building and civil-engineering work to the value of 75,000,000*l.* will be carried out on electric power stations during the next two years. Site work is in progress on 63 projects with an installed capacity of 5,260 MW, and plans for 13 more projects involving 1,205 MW have been approved.

REPAIRS TO "AUSTERITY" LOCOMOTIVES.—The Ministry of Supply announce that Belgian locomotive-repair shops are repairing 165 British "Austerity" 2-8-0 locomotives. They form part of 689 engines which are being returned from the Continent to reinforce the locomotive stock of the home railways. During the past year, 460 engines have been returned. Of the remaining 246 of the 935 shipped during the invasion, some have been sold and others are still required in the occupation of Germany.

RAILWAY MODELS AT PADDINGTON.—Four railway models, to a scale of $1\frac{1}{2}$ in. to 1 ft., have been presented to the Directors of the Great Western Railway Company by the maker, Mr. B. R. Hunt, of Johannesburg, South Africa, and are now exhibited on the "Lawn" (the circulating area) of Paddington Station, London. They comprise a model of the G.W.R. 4-6-0 express passenger locomotive "King George V"; a corridor coach of the "Cornish Riviera" express; George Stephenson's "Locomotion" No. 1; and the first closed carriage "Experiment." There is also a case of engine tools to the same scale. The "King George V" and the corridor-coach models are each 8 ft. 6 in. in length, and together weigh about 1,200 lb.

BRITISH STANDARD SPECIFICATIONS.

THE following specifications of engineering interest have been issued by the British Standards Institution. Copies are obtainable from the Publications Department of the Institution, 28, Victoria-street, London, S.W.1, at the price quoted at the end of each paragraph.

Low-Heat Portland Cement.—A new British Standard Specification, No. 1370-1947, covers a type of Portland cement intended for use in structures such as dams, where large masses of concrete have to be placed, and aims at overcoming some of the difficulties met with if ordinary Portland cement is used for this purpose. For many years, engineers have recognised that a principal cause of shrinkage cracking in large masses of concrete is the high temperature generated within the mass during the hardening period, and the consequent contraction on cooling. This problem has been studied by various authorities, and the experience gained from investigation in this country and abroad has led to the preparation of the present specification which covers a Portland cement possessing a reduced heat of hydration. This has been achieved by a reduction in the maximum permissible lime content, and by precautions as to the fine grinding of the cement, the fineness of the cement also having the effect of reducing the tendency of a concrete mix to segregate. These changes, it is stated, do not offset the ultimate strength of the cement, though the rate of strength development is appreciably lower than is the case with ordinary Portland cement. The specification defines the methods to be used in selecting samples for testing and the appropriate tests for fineness, chemical composition, strength, setting time, soundness and heat of hydration. [Price 3*s.* 6*d.*, postage included.]

Testing Vitreous-Enamel Finishes.—Another new British Standard Specification, No. 1344-1947, covers methods for testing vitreous-enamel finishes and also defines "acid-resistant" and "alkali-resistant" enamels. All methods at present in use have been investigated and after careful consideration it has been decided to limit the recommendations to methods of testing for the determination of acid resistance (qualitative and quantitative), alkali resistance, resistance to thermal shock, the heat resistance of vitreous-enamelled cast iron, and resistance to abrasion. The tests cover the main properties of vitreous enamels and their suitability for practical use. It is suggested, however, that discrimination be exercised in specifying the tests in whole or in part and a selection made from the recommended tests. Limiting figures should then be agreed upon according to the requirements. [Price 2*s.*, postage included.]

BOOKS RECEIVED.

Ministry of Fuel and Power, and British Intelligence Objectives Subcommittee. Technical Report on the Ruhr Coalfield. By a Mission from the Mechanisation Advisory Committee of the Ministry of Fuel and Power. Volume III. Appendix No. 7. *Organisation and Layout of Underground Faces in Flat and Medium Formations in the Ruhr.* By DR. ING. H. GLEBE. [Price 9*d.* net.] Appendix No. 9. *The Development of Face Production.* By DR. ENG. WALTER VOGEL. [Price 9*d.* net.] Appendix No. 28. *Reasons for Changing the Working Voltage Underground from 380 v. to 500 v.* By CARL KELLNER. [Price 6*d.* net.] H.M. Stationery Office, Kingsway, London, W.C.2.

Telegraph Transmission Theory. By E. H. JOLLEY. Sir Isaac Pitman and Sons, Limited, Parker-street, Kingsway, London, W.C.2. [Price 7*s.* 6*d.* net.]

The Foreman's Guide. For the Foreman, the Forewoman, the Manager, the Student. By R. B. HOVEY. Second edition. Sir Isaac Pitman and Sons, Limited, Parker-street, Kingsway, London, W.C.2. [Price 4*s.* 6*d.* net.]

Prentice-Hall Aeronautical Engineering Series. Elementary Applied Aerodynamics. By PROFESSOR PAUL E. HEMKE. Prentice-Hall Incorporated, 70, Fifth-avenue, New York City, U.S.A. Constable and Company, Limited, 10, Orange-street, London, W.C.2. [Price 26*s.* net.]

Plastics for Electrical and Radio Engineers. By WALTER J. TUCKER and R. S. ROBERTS. Second edition, revised and enlarged. The Technical Press, Limited, "Piccancot," Gloucester-road, Kingston Hill, Surrey. [Price 15*s.* net.]

Universal Directory of Railway Officials and Railway Year Book, 1947-1948. Compiled under the direction of the editor of *The Railway Gazette*. The Directory Publishing Company, Limited, 33, Tothill-street, Westminster, London, S.W.1. [Price 20*s.*]

Servomechanism Fundamentals. By HENRI LAUER, ROBERT LESNICK and LESLIE E. MATSON. McGraw-Hill Book Company, Incorporated, 330, West 42nd-street, New York 18, U.S.A. [Price 3·50 dols.] McGraw-Hill Publishing Company, Limited, Aldwych House, Aldwych, London, W.C.2. [Price 17*s.* 6*d.*]

PERSONAL.

After a period of eight years as its honorary treasurer, DR. DAVID HERON has been elected President of the Royal Statistical Society, 4, Portugal-street, London, W.C.2, in succession to Lord Woolton, P.C., C.H., LL.D. PROFESSOR J. H. JONES, M.A., has succeeded him as the Society's honorary treasurer.

MR. G. T. HARRIS, M.A., F.Inst.P., has been appointed research manager to Messrs. William Jessop and Sons, Limited, Brightside Works, Sheffield 1, and to Messrs. J. J. Saville and Company, Limited, Triumph Steel Works, Sheffield 1, under the present director of research, Mr. D. A. Oliver, M.Sc., F.I.M., F.Inst.P.

MR. VICTOR C. H. CREER, M.A. (Cantab.), has been appointed general manager of the lamp and lighting sales department of The British Thomson-Houston Company, Limited, Crown House, Aldwych, London, W.C.2.

MESSRS. DAVY AND UNITED ENGINEERING COMPANY, LIMITED, Park Iron Works, Sheffield, 4, announce that MR. A. POOLE, A.M.I.Mech.E., has resigned from his position as chief engineer, having passed the retiring age, and has been appointed whole-time consulting engineer. MR. W. W. FRANKLIN, A.M.I.Mech.E., has been promoted to the position of chief engineer. MR. W. CRAIG, A.M.I.Mech.E., has been appointed assistant chief engineer in charge of sectional-rolling mill design, including blooming and slabbing mills. MR. W. H. GOODLAD has been made assistant chief engineer in charge of flat-rolling mill design, including auxiliary equipment, and MR. J. G. FRITH, A.M.I.Mech.E., assistant chief engineer in charge of hydraulic machinery design. MR. R. BALLANTYNE, B.Sc., A.M.I.Mech.E., has been appointed drawing office manager. Mr. Poole has spent 40 years in the company's service, including 16 years as chief engineer.

CAPTAIN A. M. HOLBEIN, B.Sc. (Eng.), D.I.C., has received the fellowship of the City and Guilds of London Institute.

MR. F. A. FOX, M.Sc., assistant director of the British Welding Research Association, 29, Park-crescent, London, W.1, has received the degree of Doctor of Science from the University of Birmingham.

DR. ING. JOSEF WERNER BONDI, M.I.Mech.E., M.I.P.E., has been appointed a director of Messrs. British Oil Engines (Export), Limited, the export subsidiary of Messrs. Associated British Oil Engines Limited, Duke's-court, 32, Duke-street, St. James's, London, S.W.1.

MR. D. E. BUNCE has been appointed secretary of Messrs. James Booth and Company, Limited, Argyle-street, Nechells, Birmingham 7, in succession to MR. R. FRANKLIN, who has taken over the position of comptroller to the company.

MR. GEORGE WATSON, M.I.C.E., M.I.Mech.E., informs us that his address is now 20, Spencer-road, South Croydon, Surrey. (Telephone: Croydon 1051.)

MR. E. MACKAY HERIOT, M.Inst.M.M., has resumed his position as general manager of the Peña Copper Mines, Limited, Huelva, Spain.

MR. L. O'N. THOMSON, A.Inst.M.M., of the Hong-Kong Public Works Department, has been appointed Inspector of Mines, Nigeria.

MESSRS. THOMAS BUTLIN AND COMPANY, Wellingborough, Northamptonshire, first established in 1852, and recently a branch of the United Steel Companies, Limited, has been purchased by MESSRS. MORRIS MOTORS, LIMITED, Cowley, Oxford. The newly-acquired foundries will complete existing orders and will operate as a department of the engines branch of Messrs. Morris Motors, Limited, so that all Morris foundries will be under one management.

MESSRS. DAVID BROWN AND SONS (HUDD.), LIMITED, Huddersfield, have announced that MESSRS. MUIR MACHINE TOOLS, LIMITED, Britannia Works, Manchester, 3, will now be known as DAVID BROWN MACHINE TOOLS, LIMITED. The change has been made to avoid any confusion now that all the David Brown machine-tool activities are centralised. Previous changes in specialist re-organisation within the David Brown group were announced in our issue of November 22, 1946, page 490.

The BRITISH SCIENTIFIC INSTRUMENT RESEARCH ASSOCIATION have now opened their new laboratories at "Sira," Southill, Elmstead Woods, Chislehurst, Kent. (Telephone: IMPerial 2237.)

THE BUILDING CENTRE, LIMITED, 9, Conduit-street, London, W.1, announce that their telephone numbers for all sections have been changed. They are now MAYfair 8641/6.

ELECTRICITY SUPPLY IN BIRMINGHAM.—According to the annual report of the Electricity Department, the electricity sold in Birmingham during the year ended March 31, 1947, amounted to 1,298 million kWh, or 131 million kWh in excess of 1945-46. In addition, 464 million kWh were supplied to the Central Electricity Board. For the first time, over 2,000 million kWh were generated. The average cost per kilowatt-hour fell slightly, in spite of the higher prices of coal and other commodities.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel.—Full-capacity outputs are still being obtained, and the shipbuilding industry is now receiving a somewhat higher allocation. The additional steel for the yards is probably not more than 10 per cent., but this increase has solved production problems very considerably. Re-rollers are most affected by the steel shortage, billets being barely sufficient to cover 60 per cent. of full rolling needs. There is a heavy demand for sheets, but the mills are restricted for lack of sheet bars, and delivery dates have lengthened. Pig-iron production is steady, and basic supplies are ample for the steelmakers' requirements.

Scottish Coal.—Supplies have had to be allocated very sparingly to provide the fuel necessary for coke-ovens, gasworks, electric power stations, railways, and other essential services during the holiday period now commencing, and the marketing authorities have had to manage with far less coal than would normally have been available if the five-day week had not proved so disastrous to production in this area. The weekly loss is greater in quantity than the total fuel needs of the iron and steel industry, from which statement it is easy to infer how difficult it must be to cover such a tonnage loss without crippling production in industry or hindering the public services of gas, electricity, transport, and some others. Last week, the railways had to be given additional coal to prevent a breakdown in rail transport over the holiday period. This absorbed a considerable amount of house coal, and an extra allocation of open-cast coal had to be made to compensate house-coal merchants for the loss of deep-mine tonnage. Industrial users have obtained a regular and adequate supply of fuel in the past week, and their current needs are comfortably covered. Industrial stocks of coal, however, are lower than is desirable for safety next winter.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

General Situation.—With the promise of better allocations of fuel, manufacturers of many commodities hope to increase output, but consumers of iron and steel are still looking for means to ascertain to what extent they may rely on expansion in deliveries. The shortage of supplies should be reduced progressively, but results cannot be expected quickly. It is revealed that between April and May the increase in steel production on the North East Coast amounted to only 300 tons a week, and the weekly output of pig iron declined from 35,300 tons to 34,400 tons. There was also a slight shrinkage in the output of Cleveland ironstone, which, in May, amounted to only 17,800 tons a week. Adequate parcels of native ironstone and imported ore, however, are reaching the blast-furnaces, but more furnace coke is needed to permit the much needed expansion in the production of pig iron. Semi-finished material is required in larger quantities than are obtainable and there is an inconvenient scarcity of finished products.

Foundry and Basic Iron.—Larger supplies of foundry iron are being demanded. Local brands have not been made for some time and some curtailment in the regular deliveries of tonnage from other producing areas is likely. The output of basic iron is moving promptly into use at the makers' own consuming plants.

Hematite, Low-Phosphorus and Refined Iron.—The limited make of East Coast hematite is readily taken up by consumers and larger deliveries would be welcome. Low-phosphorus iron is scarce, and manufacturers of refined descriptions have ready outlets for their products.

Manufactured Iron and Steel.—Semi-finished iron is well taken up and finished-iron firms have good bookings. Steel semies are still wanted in large quantities. Re-rollers are still complaining of the shortage of billets, blooms and sheet bars. The demand for finished steel is very heavy and the acute scarcity of nearly all descriptions of material is regarded as one of the main factors impeding economic recovery. The Control is disinclined to restrict exports too severely, but advances in quotations are apparently unavoidable and the upward movements announced of 20*s.* in the export price of heavy steel and of 40*s.* on overseas sales of small steel bars and light sections caused no surprise.

EXPORT OF ELECTRICITY FROM SCOTLAND.—In reply to a question by Colonel R. S. Clarke in the House of Commons on Thursday, July 10, the Parliamentary Secretary to the Ministry of Fuel and Power (Mr. H. T. N. Gaitskell) said that during 1946 there had been a net transfer of 47 million kWh from Scotland to England. The maximum power transfer from Scotland to England was 146 MW (which occurred from 9 to 9.30 a.m. on March 14) and 80 MW from England to Scotland (which occurred from 10.30 to 11 p.m. on December 30).

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Welsh Coal Trade.—The research unit established some years ago by the South Wales and Monmouthshire Coalowners' Association to deal with problems of dust in mines, which has been mainly staffed by the Cardiff University College, is to be disbanded this month. Tribute to the excellent work done by the unit has been paid from time to time. The work will be carried on in future by the National Coal Board, and it has been announced that the Board has arranged for the South-Western and other divisions a scientific control organisation to investigate local day-to-day mining problems, especially the measurement, control and suppression of dust. During the past week, some 14,000 miners in the Rhondda Valley have been on holiday. They have formed the first instalment of the new plan to stagger holidays in the industry in South Wales. Last year the largest portion of the pits throughout the coalfield had to August Bank Holiday week for the annual stoppage. This year the stoppage will be spread over a longer period. Last week's stoppage created difficulties for operators on the steam-coal market. It meant a reduction in the supplies available, and in some cases resulted in delays in contract deliveries to inland customers. It is not expected that the loss of production this year will be made good before the usual autumnal expansion in demand makes itself felt, and consequently a difficult supply position is envisaged for some time ahead. Due to the scarcity of supplies, exports were almost impossible to ordinary foreign customers, although limited quantities of the poorest sorts were released for delivery to Eire.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Rather fuller supplies of coke have removed some of the anxieties at the blast-furnaces and made available a freer flow of pig-iron. There is not sufficient fuel to permit the operation of all steel-melting and heat-treatment furnaces and also to allow the accumulation of three weeks' reserves of coal for the winter. There are still restrictions on the use of gas, and no more licences are being granted at present for the conversion of steel plants from coal to oil fuel. It is believed that in August the resumption of the issue of licences will be possible. In spite of these handicaps there has been some improvement in steel outputs, but not sufficient to meet all the requirements of mills, tilts and forges. There is consequently a shortage of steel sheets and bars needed by the numerous steel-consuming industries of Sheffield. The labour position at the mills and forges is not satisfactory, but tends to improve as Polish labour adjusts itself to the conditions. Recruits of local origin are few and far between. Similarly, in the tool trades, there is a shortage of highly skilled operatives and no learners are coming forward. Tool factories are inundated with orders, and the agricultural-machine parts industry and the tool branches are receiving numerous orders for delivery next year. Railway-material departments are overwhelmed with orders and are doing their best with inadequate supplies of steel.

South Yorkshire Coal Trade.—Outputs of coal are disappointing, and in a few instances targets are not being reached. Absenteeism and unofficial strikes are still rife. To a small extent the loss of production of pit coal is being offset by increased production of open-cast coal at new or extended sites. Industrial coal is in relatively short supply, and manufacturers are apprehensive about the supply of washed and graded steams and boiler fuel during the winter. Slurry is offered in large quantities, but is of very little use to industry. It is being taken for the manufacture of ovoids for domestic use. Coke is in rather better supply now that a little more coking coal has been made available. Coalite is in active request.

THE WHITWORTH SOCIETY.—The Whitworth Society are holding a reception and luncheon on Wednesday, July 30, 1947, at the Holborn Restaurant, London, at 12.30 for 1 p.m. This function, according to custom, is limited to Whitworth Scholars, Exhibitioners and Prize Men. During the luncheon, Mr. Leslie H. Hounsfield, A.R.C.S., M.I.Mech.E., Wh.Ex., will retire from the presidential chair and will install as his successor Professor Andrew Robertson, F.R.S., P.P.I.Mech.E., Wh.Ex.

APPROXIMATE FORMULÆ FOR BEAM-COLUMNS: ERRATUM.—The expression for the maximum bending moment in the case of a freely-supported strut having a uniformly distributed lateral load was given, on page 25, *ante*, near the bottom of the first column, as $\frac{w l^2}{8 E I}$, whereas it should, of course, be $\frac{w l^2}{8}$. We regret the error, which, however, would be too obvious to be misleading.

NOTICE OF MEETING.

It is requested that particulars for insertion in this column shall reach the Editor not later than Tuesday morning in the week preceding the date of the meeting.

INSTITUTE OF PHYSICS.—*Industrial Radiology Group:* Friday and Saturday, July 18 and 19, Electric Lamp Manufacturers' Association, 2, Savoy-hill, Strand, W.C.2. Symposium on "Methods of Crack Detection." Friday, July 18, 10 a.m. (i) Introductory Address by Dr. W. Betteridge. (ii) "Radiological Methods," by Mr. C. Croxon. (iii) "Visual, Etching and Magnetic Methods," by Mr. P. Rowbotham. 3 p.m., various works' visits. Saturday, July 19, 9.30 a.m., Annual General Meeting for Members of the Group only. 10 a.m., (i) "Eddy-Current Methods," by Mr. A. M. Armour. (ii) "Crack Detection by Supersonic Methods," by Mr. D. O. Sproule. (iii) "Industrial Radiology in Czechoslovakia," by Mr. M. Balmler.

LAUNCHES AND TRIAL TRIPS.

S.S. "MARTIN CARL."—Single-screw general cargo vessel, built by Messrs. S. P. Austin and Son, Limited, Wear Dockyard, Sunderland, for A/S Dampskibsselskabet "Heimdal," Copenhagen. Main dimensions: 307 ft. by 45 ft. by 20 ft. 3 in. to main deck; deadweight capacity, about 3,390 tons on a summer draught of 19 ft. 1 in. Triple-expansion engine of reheat design supplied by the North-Eastern Marine Engineering Company (1938), Limited, Sunderland, to give a service speed of 13 knots. Trial trip, July 2.

S.S. "POUL CARL."—Single-screw general cargo vessel, to the same particulars as for the S.S. "Martin Carl." Launch, July 3.

S.S. "AIDA."—Single-screw cargo vessel built by Messrs. Short Brothers, Limited, Pallion, Sunderland, for Messrs. Rederi A B Soya, Stockholm. Main dimensions: 441 ft. 6 in. overall by 57 ft. by 36 ft. 10 in. to shelter deck; deadweight capacity, about 9,050 tons on a draught of 25 ft. 1¾ in. Triple-expansion engine of reheat type supplied by Messrs. George Clark (1938), Limited, Sunderland, the associate firm of the North Eastern Marine Engineering Company (1938), Limited, Wallsend-on-Tyne. Trial trip, July 7.

M.S. "BOWGRAN."—Single-screw cargo vessel, built by the Burntisland Shipbuilding Company, Limited, Burntisland, to the order of A/S Nye Kristianborg, Minde, Bergen (A/S Rederiet Odfjell). Main dimensions: 397 ft. by 55 ft. 6 in. by 36 ft.; deadweight capacity, 7,700 tons on a draught of 25 ft. 1 in. Four-cylinder Hawthorn-Doxford opposed-piston Diesel engine of 4,400 brake horse-power, supplied by Messrs. R. and W. Hawthorn, Leslie and Company, Limited, Newcastle-on-Tyne. Trial trip, July 12.

THE ROYAL STATISTICAL SOCIETY'S LIBRARY.—The library and reading rooms of the Royal Statistical Society, 4, Portugal-street, London, W.C.2, will be closed from Saturday, July 19, to Saturday, August 16, inclusive.

OIL-BURNING LOCOMOTIVES.—In a written answer to Sir J. Lucas in the House of Commons on Thursday, July 10, the Parliamentary Secretary to the Ministry of Transport (Mr. G. R. Strauss) said that 37 locomotives (out of 1,200) had been equipped for oil burning so far, and nine were at present undergoing conversion.

JUBILEE OF THE MARCONI COMPANY.—The jubilee of Marconi's Wireless Telegraph Company, Limited, falls on Sunday, July 20, and, as already announced, has been officially celebrated by a Convention of Marconi representatives in London from all parts of the world, by an exhibition, and by the publication of a commemorative book. It may be mentioned that the original secretary of the company, Mr. H. W. Allen, is still living, while other early members of the company living are Mr. C. E. Rickard, who joined in 1898, and Messrs. A. Gray, C. S. Franklin, H. M. Dowsett, P. J. Woodward and W. Densham, whose service dates from 1899.

KRUPP'S LOCOMOTIVE WORKS, ESSEN.—In reply to a question by Mr. R. R. Stokes in the House of Commons on Monday, July 14, the Minister of State (the Rt. Hon. H. McNeil) said that no part of Krupp's Gusstahlfabrik at Essen, which was normally engaged on locomotive production and was required for the locomotive-building programme, had been scheduled for demolition. Other sections of the factory, which were normally engaged on locomotive work and were required for locomotive repairs, were also exempted from the present demolition and reparation programme. He was anxious to ensure that there was no loss of potential plant for locomotive production.

EXHIBITS AT THE ROYAL AGRICULTURAL SHOW, LINCOLN.

(*For Description see Page 53.*)

FIG. 9. MID-MOUNTED TOOL BAR; MESSRS. MARTIN'S CULTIVATOR COMPANY, LIMITED.

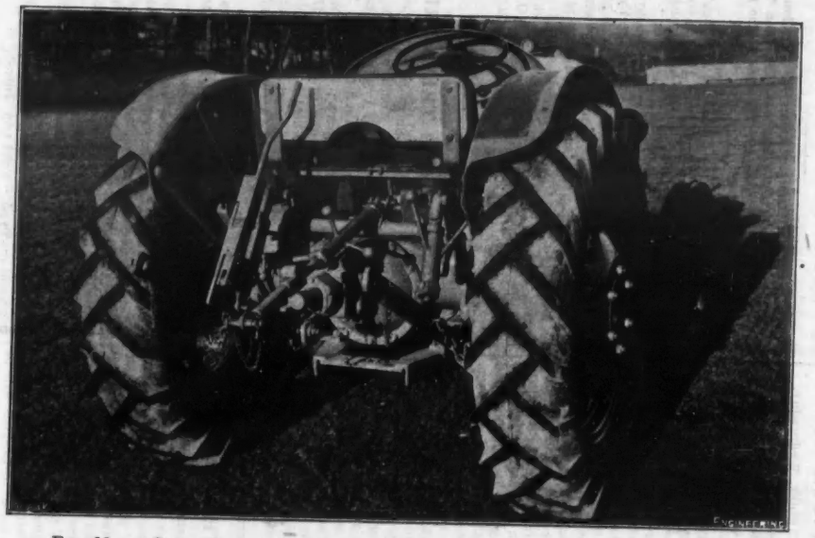


FIG. 11. "CROPMASTER" TRACTOR; MESSRS. DAVID BROWN TRACTORS, LIMITED.

FIG. 10. 5-TON WINCH; MESSRS. DARLINGTON ENGINEERING COMPANY (GATESHEAD), LIMITED.

FIG. 12. DIESEL-ENGINED TRACTOR; MESSRS. MARSHALL, SONS AND COMPANY, LIMITED.

ENGINEERING.

35 & 36, BEDFORD STREET, STRAND, LONDON, W.C.2.

We desire to call the attention of our readers to the fact that the above is the address of our Registered Offices, and that no connection exists between this Journal and any other publication bearing a similar title.

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SUBSCRIPTIONS.

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For Canada	£4 5 0

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ADVERTISEMENT RATES.

Terms for displayed advertisements on the green art paper wrapper, on the inside black and white pages and in the buff art paper two-colour supplement, as well as for inserts, can be obtained on application to the Manager. The pages are 12 in. deep and 9 in. wide, divisible into four columns 2¼ in. wide. Serial advertisements will be inserted with all practicable regularity but absolute regularity cannot be guaranteed.

The charge for advertisements classified under the headings of "Appointments Open," "Situations Wanted," "Tenders," etc., is 8*s.* for the first four lines or under, and 2*s.* per line up to one inch. The line averages six words and when an advertisement measures an inch or more, the charge is 24*s.* per inch. If use is made of a box number the extra charge is 1*s.* per insertion, with the exception of advertisements appearing under "Situations Wanted." Series discounts for all classified advertisements can be obtained at the following rates:—5 per cent. for six; 12½ per cent. for thirteen; 25 per cent. for twenty-six; and 33⅓ per cent. for fifty-two insertions.

TIME FOR RECEIPT OF ADVERTISEMENTS.

Classified advertisements intended for insertion in the current week's issue must be received not later than first post Wednesday.

"Copy" instructions and alterations to standing advertisements for display announcements must be received at least 10 days previous to the date of publication, otherwise it may be impossible to submit proofs for approval.

The Proprietors will not hold themselves responsible for advertisers' blocks left in their possession for more than two years.

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ENGINEERING

FRIDAY, JULY 18, 1947.

VOL. 164. No. 4251.

THE PRACTICAL TRAINING OF PROFESSIONAL ELECTRICAL ENGINEERS.

DURING the present century the use of electricity has increased at a rate which it is difficult to describe without seeming to exaggerate. This development has occurred in two planes; not only has utilisation expanded in the particular fields into which the subject is divided, but the number of applications has become greater almost year by year. Empiricism has been replaced by exactitude and the study of fundamental principles has become almost more important than that of practical application. This is the natural outcome of the work of many devoted protagonists, a large proportion of whom had received little or no formal scientific or technical education. This has now changed, however, and, as a direct result of this development, it has become increasingly evident that recruits to the profession must receive a training combining the scientific and the technical, the theoretical and the practical, if they are to be fitted to undertake the arduous duties connected with the manufacture, installation and operation of electrical equipment. The Institution of Electrical Engineers has devoted much attention to the ways and means by which this training can best be organised and acquired and already has published two reports, one dealing with the education and training of engineers,* in which existing systems were reviewed, while the other contained proposals for the development of part-time further education at technical colleges.† These reports have now been followed by a third of a more specialist character, prepared by a committee representative of the Institution, the British Electrical and Allied Manufacturers Association and the Radio Industry Council, under the chairmanship of Sir Arthur P. M. Fleming.

This report‡ deals specifically with the practical training of the professional electrical engineer, who is defined as "one who, by virtue of his general and technical education, practical training and subsequent experience is fitted to undertake work requiring a high degree of personal responsibility in one or more branches of engineering." He is thus distinguished from the technician, whose skill lies in the practical application of a knowledge of engineering technique in a particular field; draughtsmen, erection engineers and senior testers, for instance, would be included in the latter group. He is also distinguished from the third class, of craftsmen, more precise definition of whom is unnecessary. It must be emphasised that, with a few trifling exceptions, the report deals solely with the professional electrical engineer and that, with the same reservations, the recommendations made apply only to that class. It contains little that is novel; as explained by Sir Arthur Fleming, its purpose is rather to codify existing methods, and thus to ensure that the practical training essential for the young engineer is carried out in the best possible way. It deals mainly in generalities and the schemes proposed are sufficiently flexible to enable them to be adopted in principle by both large and small firms.

There are at present two principal methods whereby young men can obtain the technical education necessary to qualify them as electrical engineers, or, in other words, for admission to the Institution. There are the full-time university course, lasting three or four years and leading to a degree; and the part-time course at a technical college, lasting four or more years, and leading to the Ordinary and Higher National Certificates. These courses must be supplemented by appropriate schemes of practical training. It is recommended that those who have taken the full-time course should undergo a two-year "graduate apprenticeship," one year of which ("pre-graduate apprenticeship" should be served, if possible, before the main course is started. It is also recommended that those who take the part-time educational course should undergo a four-year "student apprenticeship." No attempt is made to place these alternatives in order of merit, it being argued, rightly, that the choice is governed by the candidate's aptitude, interests and circumstances. Industry requires men of both types and both will have equal opportunities for advancement to positions of senior responsibility. A desirable condition for entry to a pre-graduate apprenticeship is the possession of the Higher School Certificate, while for the graduate apprenticeship a pass degree in electrical engineering or an honours degree in physics is essential. A candidate for admission to a student apprenticeship should possess a Leaving Certificate of good standard from a secondary school and should preferably be between 16 and 17 years of age. In selecting candidates, personality, general intelligence and scientific knowledge are regarded as the chief qualifications.

As regards the lines the practical training should follow, it is laid down that the main objects of the course are to familiarise the apprentice with the materials, tools, equipment and craft skill available in modern industry; with the techniques and organisation involved in designing, developing, manufacturing, installing and operating engineering equipment; and with the outlook of the men he will be required to control during his professional career.

With these objects in view, the schemes of training for each class of apprentice are divided into three parts: mechanical, electrical and office. The first, which, it is suggested, should occupy nearly half the course, will give the apprentice an acquaintance with workshop methods and factory organisation. The second will provide him with opportunities for widening his knowledge of the properties of materials used in electrical engineering and of the various methods involved in assembling and testing electrical equipment. The final period will introduce him to the office work connected with production and design of this equipment, besides affording him an opportunity of deciding whether he would care subsequently to specialise in one of the seven broad groups of functional activity—research, design, production, marketing, installation, operation and

* See ENGINEERING, vol. 155, page 393 (1943).

† See ENGINEERING, vol. 159, page 52 (1945).

‡ *The Practical Training of Professional Electrical Engineers.* The Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2. [Price 1*s.*]

education. In the case of graduate apprentices, the university vacation should also be utilised for gaining practical experience in operation or erection, or for indulging in foreign travel.

The report also contains what may be described as a specification of the professional electrical engineer. According to this, upon him is laid the primary responsibility for guiding, controlling and maintaining the progress of the electrical industry. In order to do this, he must be well grounded in the fundamentals of natural science, upon which the industry rests, be acquainted with the organisation and management of engineering concerns and appreciate the economic and human factors affecting his own branch of the industry. Finally, his mind and character should be so trained that he can apply himself with intelligent determination to the technical and human problems which will come before him. This is, perhaps, more than little reminiscent of the qualifications of a model major-general as enunciated by W. S. Gilbert in *The Pirates of Penzance*, and may lead some to wonder, cynically, whether such Admirable Crichtons really exist, either in embryo or in the finished state. Later, we were not surprised to be informed that the demand for professional electrical engineers is likely soon to outrun the supply. It may be argued that while, in view of the present state of the industry and the developments which are likely to take place, it is necessary to place the standard high, there may be disadvantages in placing it too high. It is true, if trite, to say that there will always be room at the top. It is equally true, if less trite, to say that there will always be room a little lower down, where also there is much useful work waiting to be done. An army cannot be made up entirely of generals; or, in the words of the late Sir Ernest Moir, "There is no point in turning out hundreds of surplus turbine-designers when the world really wants good plumbers."

We prefer, however, to think that this Committee of distinguished engineers have been rather carried away by their own enthusiasm in framing the report and that, in seeking to secure, as is essential, that the future electrical engineer shall have rather more than adequate qualifications, they have been a little more pontifical than they intended. This conclusion is induced by the discovery that the report recognises that there is another side of life than the professional, and therefore rightly stresses the necessity of encouraging apprentices to take part in and organise social, athletic and educational activities outside working hours. The danger that the classes of apprenticeship with which the report deals might crystallise into a hierarchy is also recognised and the formation of an Apprentice Association is recommended—presumably, and preferably, in our opinion, for apprentices of all the grades mentioned. This will assist in stimulating that human interest which, it is obviously felt, should be as much part of the equipment of the professional electrical engineer as technical knowledge. Nevertheless, it is clear that the young man who desires in future to rise to any eminence in electrical engineering will require not only considerable intellectual and practical qualifications, but a deep sense of vocation, great powers of application, and, above all, good health. If he does not possess these qualifications, he will sooner or later feel that a life less real and earnest and more dilettante has greater attractions and will decide that a change of employment is essential. That would be a pity in many cases, besides being economically wasteful.

The recommendation that the candidate should undergo one year of practical training before taking his university course is sound. Such a procedure would have the effect of weeding out those who have embarked on engineering owing to the mistaken encouragement of their parents or their own wishful thinking, and of thus saving the time of those whose duty it will be to supervise subsequent training. In any event, the boy is asked to make a grave decision at an early age; some wastage is probable, therefore, and the more that it can be reduced the better. From many points of view, this report is worth close study and it is to be hoped that there will be no undue delay in implementing it.

MODERNISATION OF THE IRON AND STEEL INDUSTRY.

MUCH of a general character has been said and written in the past couple of years about the need to modernise the equipment of the British iron and steel industry and the financial outlay which the industry has undertaken to meet to this end, but the more spectacular plant extensions envisaged have tended rather to obscure the very considerable alterations and improvements which have been and are proceeding in almost every district where iron and steel are produced. The time was opportune, therefore, for the publication of the details of these improvements which have been revealed recently by the British Iron and Steel Federation. They relate to plants in Sheffield, Bradford, the North-East Coast, Workington and Scunthorpe, and involve an aggregate expenditure of many millions of pounds. The fact that some of the schemes now nearing fruition have been in hand for a number of years should provide an effective reply to suggestions that it was only the threat of nationalisation which spurred the companies concerned to the point of bringing their plants more up to date.

The scheme in hand at the Consett Iron Works, which is to cost some 3,000,000*l.*, is notable for the emphasis laid on the avoidance of heat losses by the maximum utilisation of thermal energy in the various processes. The new plant includes two batteries of Becker coke ovens, three blast furnaces and a boiler plant and power house containing five Clarke Chapman boilers, designed to generate 100,000 lb. of steam per hour each at 450 lb. per square inch, two 15,000-kW alternators, and two turbo-blowers to deliver 50,000 cub. ft. of air per minute at 25 lb. per square inch pressure. Three of the new boilers will be fired with coke breeze and the other two with blast-furnace gas. The increased gas supply from the new blast furnaces will fire the new coke ovens and leave a substantial surplus, enabling the gas producers in the open-hearth shop and the mills to be eliminated, with a saving of between 2,000 and 3,000 tons of coal weekly. All the open-hearth furnaces are being converted to use gas and liquid fuel in any desired proportions. The effect of the new blast furnaces will be to increase the production of pig iron by fully 50 per cent. over the present figure of 6,000 tons weekly. When the scheme is completed, the only fuel brought into the plant from outside will be coking coal to the ovens, and breeze or low-grade coal to the boilers.

Messrs. Dorman Long and Company, are erecting at their Cleveland Works an ore preparation plant to handle 2,500,000 tons of ore annually, and sinter 350,000 tons. This will enable them to discharge at the one point all the ore required for their group of works. The ore for the Cleveland Works will be taken to the blast furnaces by belt conveyor, and the supplies to the Redcar and Acklam works by rail, with electric haulage. The use of transporter cranes, and the extension and improvement of the discharging berths for the ore ships, are expected to reduce the discharging time from five days to two days per ship. Three new boilers, each with a normal evaporation of 100,000 lb. an hour at 450 lb. per square inch, are being installed at the Cleveland Works in replacement of existing plant; they will be fired with blast-furnace gas, supplemented by coke breeze if necessary, and will be controlled automatically The existing turbines will be retained, although the working pressure of the new boilers will be higher than the present figure, but a new pass-out turbo-alternator is being installed, which will supply the low-pressure steam requirements. Other Dorman Long developments include an extension of the main constructional department which will add 200 ft. to all six bays (in all, a width of 500 ft.) of the present shops.

Another 3,000,000*l.* reconstruction scheme is that now well advanced at the United Steel Companies' Appleby-Frodingham Works at Scunthorpe, Lincolnshire. The two main items in this programme are the replacement of the present Frodingham melting shop by a new melting shop, which it is hoped to complete this year; and the reconstruction and electrification of the section rolling mills. These developments will be followed by the dismantling of the old Frodingham blast furnaces, and their replacement by an extension of the newer furnace plant already in operation. The rolling mill will be rearranged, with the cogging mill, and the first and second roughing mills, differently disposed, to give more working space. The cogging mill will be new, and should give an output of 5,000 to 5,500 tons a week. The electric drive to the mills will comprise two Metropolitan-Vickers motors, of 5,500 h.p. and 5,000 h.p. continuous rating, respectively. The ingot preheating furnace has been rebuilt and two new soaking pits are to take the place of the present pits. The new drives will release about 1½ million cub. ft. per hour of blast-furnace gas for other purposes. The new melting shop is being built on a site rather more than half a mile from the section mill and will use this surplus gas, with added coke-oven gas; liquid-fuel firing will be available as a standby. The present producer-gas plant at Frodingham can then be dispensed with, thus saving 800 tons of coal weekly. The new shop will have two tilting furnaces with a combined output of about 200,000 tons of ingots per annum. Two new blast furnaces will be erected at the South Ironworks, more than doubling its present capacity.

The developments mentioned as taking place in the Sheffield area are those of Messrs. Steel, Peech and Tozer, Limited, and Messrs. Samuel Fox and Company, Limited. The former firm installed a new cogging mill about three years ago, increasing their output some 20 per cent., and are now converting eight of their 21 furnaces to oil firing and two to tar firing. The railway-wheel mill is being re-equipped and a new mill constructed adjoining it, increasing the production of railway material about 30 per cent. The new plant will be electrically driven instead of by steam, and will include a 6,000-ton forging press, a vertical wheel-rolling mill, and reheating furnaces fired with coke-oven gas. Eighteen waste-heat boilers are to be installed in the melting shops in the next two years and are expected to save about 19,000 tons of coal per annum. Messrs. Samuel Fox and Company have been engaged for several years on a programme of reconstruction, at a total cost of over 1,000,000*l.*; though the individual items are, perhaps, less spectacular than some of those mentioned above, the highly specialised and varied nature of the products make these extensions of particular importance. They include cold-rolled carbon-steel strip for clock and instrument springs, razor blades, etc.; wire for motor-car valve springs; welding wire; and the fine wire used for electrical resistances. The laminated-spring shop, newly re-organised when we described it on page 148 of our 144th volume (1937), is being further modernised and extended, and largely re-equipped.

There remain to be mentioned the 200,000*l.* reconstruction of the continuous rod mill at Messrs. Richard Johnson and Nephew's Bradford Ironworks; and the very extensive modernisation of the plant of the Workington Iron and Steel Company, begun as a long-term plan in 1932 and now nearing completion at a total outlay of 3,250,000*l.* Messrs. Johnson and Nephew's output will be approximately doubled by the replacement of their old mill by the new 19-stand straight-through two-strand continuous mill. The substitution is being made by stages to avoid interference with production, the semi-finishing and finishing stands being already partly in use. When this replacement is completed, the wire mill will be taken in hand for modernisation, and the galvanising plant is to have its capacity increased by about 30 per cent. The Workington Company's scheme is exceptional, as it includes the development of a new iron-ore mine at Hale Moor, near Egremont, with its crushing, screening and sintering plants. There is also a new coke-oven plant. The plan comprises also the complete rebuilding of the blast-furnaces and associated plant at Workington, the replacement of the acid-Bessemer steel plant, the modernisation of the rolling mills, two additional boilers, each of 100,000 lb. per hour capacity, and an extension of the generating plant. When these extensions are completed, no coal will be required for power generation and a surplus of electric power will be available for distribution elsewhere.

NOTES.

THE CHEMICAL RESEARCH LABORATORY, TEDDINGTON.

THE Chemical Research Laboratory, at Teddington, Middlesex, of the Department of Scientific and Industrial Research, was built in 1924, and research work was commenced a year later. The Laboratory undertakes chemical researches of a fundamental nature, which are not otherwise adequately catered for, and the development of industrial applications therefrom; chemical researches for other stations of the Department and for other Government departments; and chemical researches of a fundamental or industrial nature at the request of industry. Investigations carried out at the Laboratory since its inception have led to several notable developments, including the anti-corrosion anodic oxidation of aluminium; the discovery of the ion-exchange resins for the plastics industry; research on the composition of tars obtained by the low-temperature carbonisation of coal, and utilisation of some of the products, particularly the tar acids; and the investigation of rarer elements and the development of methods for the separation of gallium and germanium from flue dusts. Many problems were investigated for the Service and Supply Ministries during the war, notably in connection with the development of the C.R.L. rotor test for accelerated immersed corrosion, which was used for testing anti-corrosion coatings for ships; corrosion inhibitors, such as sodium benzoate, as an aqueous solution, or incorporated in wrapping materials for the protection of machined parts; plastics, especially for the Ministry of Aircraft Production; and the production of an inexpensive fire-fighting foam from indigenous material. Researches being undertaken at present include further investigations into the corrosion of metals, including micro-biological corrosion, particularly in soil by the influence of sulphate-reducing bacteria. In the inorganic section, physical and micro-analytical methods of analysis are being developed. In another section, investigations are being undertaken on improved plastics and the correlation between structure and properties of high polymers and plastics. Work on the isolation and identification of coal-tar constituents and related products, and also the determination of their physical and physico-chemical constants, and new uses for them, is being undertaken in the coal-tar section. Lastly, in the organic intermediates section, work is proceeding on high-pressure operations, and the preparation of compounds capable of polymerisation or co-polymerisation, including those containing silicon. The Laboratory contains 33 individual laboratories, a drawing-office, two well-equipped workshops, a glass-working room, and a library. The present Director is Professor R. P. Linstead, C.B.E., F.R.S., F.R.I.C., who was appointed in 1945. His staff numbers about 100.

THE GAUGE AND TOOL MAKERS' ASSOCIATION.

His Excellency the Hon. Lewis W. Douglas, the United States Ambassador, was the principal guest at the fourth quarterly luncheon of the Gauge and Tool Makers' Association, held in London on Thursday, July 10, under the chairmanship of Mr. F. W. Halliwell, President of the Association, who was supported by the chairman of the Association (Mr. H. S. Holden), the vice-chairman (Mr. A. L. Dennison), the treasurer (Mr. R. Kirchner), and other members of the Council. His Excellency's address to the members and their guests was, he asked, not for general publication, but it may be said that, as a plea for the closest co-operation between Britain and the United States, it was surely one of the most thoughtful and forceful arguments presented to any gathering of British industrialists since the great war-time speeches of President Roosevelt and Mr. Winston Churchill, and, if anything, gained additional force from the easy and almost conversational manner of its delivery. The President having acknowledged His Excellency's address, Mr. Holden proposed the toast of "The Guests," to which Sir Alfred Herbert and Sir Patrick Hannon responded. Sir Alfred, like the Ambassador, emphasised the dependence of the future of Britain, of Europe and of America on close and sincere co-operation. To deal with enemies during the war, he said, was a hard task but comparatively simple; the pursuit of friendship was a much happier undertaking but, in many respects, more complex. Britain's latent powers of recovery were great, but they could be fully developed only if certain fundamental truths were accepted and acted upon: we must appreciate that the popular doctrine of less work for more money was false; that constantly increasing wages, unless related to higher output, merely increased the inflation which was the greatest and most pressing danger; that restrictive practices in industry recoiled on those who encouraged them; that strikes, whether official or unofficial, were wars against the community; that full employment—a most attractive ideal in theory—did not, in practice, result in maximum efficiency or a reasonable discipline in industry; and that, human nature being what it was, the only real incentives were those which directly affected the individual concerned. It was an encouraging sign, Sir Alfred concluded, that many of these truths were being realised at last both by Ministers and by trade-union leaders, many of whom had long ignored them. Sir Patrick Hannon said that the fundamental consideration was that Britain and the United States should march together, exchanging views and confidences, and hiding no salient factor in their relations which would mar success in their objective.

SIGNALLING LAMPS FOR MERCHANT SHIPS.

The Ministry of Transport announce that, in future, British merchant ships of 150 tons gross or more, making international voyages, will be required to carry electric daylight lamps of not less than 60,000 candle-power for signalling purposes. These lamps will have a range of five miles on a normal bright day in home waters, and are to replace the oil lamps now carried, on a date which is not yet fixed. The type of oil lamp now used is based on a specification introduced during the 1914-18 war, but is not powerful enough for daylight signalling and has a further shortcoming that it cannot be sighted accurately on the intended recipient of the signal. The new type of lamp, which will be similar to those used by the Royal Navy, and also by many merchant ships during the recent war, will have a sighting device. The specification drawn up by the Ministry of Transport (copies of which can be obtained from the Marine Safety Division of the Ministry, Berkeley-square House, London, W.1) requires, *inter alia*, that the lamp and battery, in their boxes, shall weigh together not more than 38 lb. and shall be readily transportable by one man; the lamp alone must not weigh more than 6 lb. The illumination is required to be by a bulb with a life of not less than 50 hours at the voltage given by the battery after 15 minutes of discharge. Normally, the current will be taken from a battery of sufficient capacity to operate the lamp continuously for at least two hours and weighing not more than 26 lb. in its box, but the lamp may be provided also with a transformer or resistance to enable the current to be taken from the ship's mains. The beam is required to have a horizontal and vertical divergence of not more than 3 deg. from the axis, this divergence being defined as the angular limits of the beam where the candle-power has fallen to one-tenth of the axial candle-power. In addition, the candle-power of the beam in every direction within an angle of 0·7 deg. from the axis shall be not less than 50 per cent. of the axial candle-power. The light must be continuous, the signalling being effected by the movement of mirrors and/or lenses, or by shutters. The movement of the mirror, lens or shutter must be by a key or trigger requiring a pressure of not less than 12 oz. or more than 17 oz., and designed so that an operator can transmit at a rate up to 12 words a minute when wearing "very thick" gloves. Provision is to be made for mounting on the lamp an easily removable shade to reduce the axial candle-power to between 8 and 15, giving a range of a mile at night in clear moonlight. Manufacturers wishing to make the new type of lamp will be required to submit a specimen to the National Physical Laboratory for testing. For satisfactory lamps, certificates of approval will be issued by the Ministry, and the accepted lamps will be placed on an approved list.

OBITUARY.

MR. J. J. KING-SALTER, Wh.Ex.

THE death, on July 13, at his home in Wokingham, of Mr. J. J. King-Salter, formerly Deputy Director of Dockyards at the Admiralty, removes one more of the relatively small, but distinguished, band of recruits to the Royal Corps of Naval Constructors who entered the Constructive Branch from private shipyards; Mr. King-Salter was, in fact, the first private student of the Royal Naval College to do so. Though he spent much of his service overseas and had been retired for more than 20 years—he was 81 years of age—few names were better remembered than his in the R.C.N.C.

Julian James King-Salter was born in 1865 at Gorleston, Norfolk, and, after a general education which included some years at Trinity Hall, Cambridge, he was apprenticed in 1885 to Messrs. John I. Thornycroft and Company, Limited, whose shipyard at Chiswick was already noted for high-speed craft. Four years later, he entered the Royal Naval College, Greenwich, completing his course there in 1892. While taking it, he gained a Whitworth Exhibition. On passing out of the College, he was given the opportunity to enter the Royal Corps of Naval Constructors and did so, being appointed first to H.M. Dockyard, Portsmouth. He served at sea for nearly two years, being one of the first constructive officers to have this experience, and then was sent to Sheerness, in charge of the drawing office. In 1900, he went to Chatham in a similar capacity, and a year later began one of his several periods of service overseas, as Chief Constructive Officer at Simonstown Dockyard, Cape of Good Hope, where he spent six years. He returned to Chatham in 1907, being promoted Constructor. In 1913, when the Australian Commonwealth Government laid out the Cockatoo Island shipyard and desired the services of an experienced Admiralty man to take charge of it, Mr. King-Salter was selected for the post, which he took up in 1914 and held for six years. It was while there that he was led to investigate the properties of launching tallows and carried out a series of experiments, the results of which were embodied in a paper that he contributed to the Institution of Naval Architects in 1921. It was reprinted on page 405 of our 111th volume (1921) and included a description of an instrument—on the lines of a Brinell hardness tester—which he devised for comparing the hardness of tallows. His next appointment was to Hong-Kong Dockyard, where he spent two years, being recalled in 1922 to take charge of the Constructive Department at Rosyth. A transfer to Devonport followed, and, finally, the appointment as Deputy Director of Dockyards, the post which he continued to hold until his retirement in 1926.

MR. W. WELLESLEY WEAVER.

WE have learned with regret of the death on July 11, at the comparatively early age of 57, of Mr. William Charles Wellesley Weaver, chairman of Messrs. Waygood-Otis, Limited, and, until a fortnight ago, their managing director. Mr. Weaver, who was a native of St. John's, Newfoundland, came to this country in his childhood and received his general education here before being apprenticed to the firm of which he became eventually the head. After a training which included all departments of the business, he travelled extensively on the Continent and in Egypt in charge of lift-engineering contracts until the outbreak of war in 1914, when he enlisted in King Edward's Horse. After demobilisation, he returned to Messrs. Waygood-Otis, Limited, serving for some time as their City representative in London, and subsequently, for some years, in India and Australia. After a further spell in London, he went to the United States to study the latest American lift practice, and, in 1933, having returned once more to London, was appointed managing director. His appointment as chairman dated from 1942. He was also chairman of Messrs. Waygood-Otis (South Africa), Limited, and a director of Messrs. Waygood-Otis (Australasia) Proprietary, Limited, and Messrs. Waygood-Otis (New Zealand), Limited.

LETTERS TO THE EDITOR.

THE ENGINEERING PROFESSIONS AND THE INSTITUTIONS.

TO THE EDITOR OF ENGINEERING.

SIR,—Mr. J. H. W. Turner's article, on page 447 of your issue of May 30, has evidently focused attention on the very real problem facing professional engineers, judging by the ensuing letters. It is my view, however, that the crux of the situation has not been correctly stated.

The majority of engineers work as employees of industrial or other organisations and, in this respect, are in a similar position to that of the majority of workers in other branches of science, such as chemistry, physics, etc. It is not correct to argue a special case for workers in engineering science, neither is it so to compare them with doctors, dentists, etc., to their disadvantage by way of remuneration and status—except, perhaps, in the case of independent consultants, who are very few in number among engineers by and large. This differentiation has great bearing on the question, as I will attempt to explain.

Doctors, dentists, etc., and consulting engineers, are, with few exceptions, self-employed and thus are able largely to determine their own economic status. Industrial scientists (of whom engineers form a branch) as employees are subject to the same law which, through industrial history, has regulated the economic conditions of the employed classes, namely, the minimum that they will accept in return for their labours. Industrial history shows us, further, that these conditions improve directly and only as do the collective powers of particular sections of workers to bargain with their employers. This, of course, leads us at once to the trades unions.

Mr. Turner touched on this question relative to professional engineers, but dismissed it briefly because of the contempt in which they usually hold trade unionism. This attitude is not surprising bearing in mind that the "middle class," from which professional workers are usually drawn, has developed on the prejudice that it is higher than the "working class," so that such organisations as trades unions are beneath its dignity. It is also fostered by employers who, naturally, wish to treat the "brains" of their industries on their own terms.

However, prejudice against trades unions does not negative the reasons for their existence. Surely this attitude is illusory, for is not any individual who, for monetary reward, sells an ability, be it manual or mental, a "worker," and therefore "working class" in the sense in which economics subdivides our society? Scientific and technical workers are suffering to-day because they have not kept pace with other sections of workers in developing their collective bargaining power. Can it be that the growing discontent among engineers is due to a slowly dawning realisation of these facts? The indications from the correspondence in your columns would appear to confirm this, but is it the correct solution to look to the institutions? While recognising their indispensable work for engineering science, one may ask, are they suitably constituted to negotiate improved economic conditions for engineers? I submit that they are not.

The institutions have developed with employers as their main sponsors, as one would expect from the financial aspect. It follows that, in general, the employers hold majorities on the governing bodies. It becomes understandable, therefore, why one of the main points of the institutions' charters should be that no direct action for the economic betterment of members will be undertaken. Drastic changes in the composition of the governing bodies, as well as revision of the charters, would be necessary before economic conditions of members could become a declared concern of the institutions.

Finally, then, is not the only conclusion that, for professional engineers and employed scientists and technicians generally, as for other workers, the problem is a trade-union one, however unpalatable this may be to many of them? If so—and, in my view, this is the case—much needs to be done to develop sufficient collective strength. The Association of Scientific Workers seems to be the only body tackling the problem.

Yours faithfully,
I. K. GOUGH, B.Sc.(Eng.).

Manor Farm,
North Wick,
Dundry, Somerset.
July 8, 1947.

TO THE EDITOR OF ENGINEERING.

SIR,—In his letter on page 41, *ante*, "Lecturer in Mechanical Engineering" implies that those who have obtained a pass in the membership examination of a leading (engineering) institution are, *ipso facto*, not only efficient slide-rule operators, but are also well educated and possess "a command of standard English, both as regards good hand-writing and speech free from accent or brogue."

Passing the Common Preliminary Examination at the studentship stage may have ensured his being basically well educated, with a command of standard English and possibly—though very doubtfully—good handwriting, but by what test is the speech of the successful candidate for associate-membership found to be "free from accent or brogue"? I venture to suggest that it would not have occurred to many of your readers that an A.M.I.C.E., A.M.I.Mech.E., and A.M.I.E.E. had passed such a test; nor, I think, in these days, would the respective membership committees contemplate its imposition with equanimity.

Yours faithfully,
B. C. CURLING.

7, Churchill-avenue,
Kenton, Harrow.
July 14, 1947.

THE DESIGN OF COMPOUND CYLINDERS FOR HIGH-PRESSURE SERVICE.

TO THE EDITOR OF ENGINEERING.

SIR,—Mr. T. McLean Jasper's letter in your issue of July 4, page 16, in commenting on my article which you published in your issue of May 2, page 349, refers to bursting pressures being indicated by the Lamé formula. This is derived from the elastic theory, as I endeavoured to show in my article, and should not, therefore, be applied in cases where non-elastic straining takes place. In my experience no cylinder of ductile material bursts without considerable plastic deformation unless the internal pressure is applied with explosive violence.

Mr. Jasper also states that "it is now becoming a well-known fact that a thick steel vessel will invariably fail with very little stretch of metal." He goes on to explain that this applies with wall thicknesses over 3 in.; for walls thinner than 1 in. the vessels become barrel-shaped before bursting. This is to me a very surprising statement. I have no personal experience of tests to destruction of cylinders with 3-in. walls, but I have tested a number of smaller ones. The results obtained, as well as those of other published work, with few exceptions, conform with the behaviour which I described in the article which you published in ENGINEERING, vol. 159, pages 101 and 183 (1945). Briefly, the conditions which affect the type of failure are: mechanical characteristics of the material, especially yield point and rate of strain-hardening; ratio of wall thickness to diameter (and not thickness alone); and rate of application of pressure. Increase of any of these reduces the amount of stretch in the external diameter at the bursting point.

It is evident that there are many factors to be taken into account, and I am certainly not claiming that the ideas I have mentioned tell the whole story. It would appear, however, that Mr. Jasper's statement is based on researches which have not received much publicity, and it would be interesting to have more details.

Mr. Jasper's chart of temperature correspondence in different metals is instructive, although it can hardly be more than empirical. The results, moreover, must be approximate only, since the theory takes no account of the effect of small additions of other elements, such as carbon in steel, which, though profoundly affecting the physical properties of a metal, have little influence on its melting point.

Yours faithfully,
W. R. D. MANNING.

EFFECT OF CENTRIFUGAL FORCE IN AXIAL-FLOW TURBINES.

TO THE EDITOR OF ENGINEERING.

SIR,—In your issue of July 4, on page 17, Mr. Pochobradsky writes that I have not proved him wrong in claiming that free-vortex flow must be inefficient. In point of fact, he had himself shown, in his original article in your issue of March 21, 1947, page 205, that free-vortex flow was different from constant specific-mass flow. His error lay in assuming that free-vortex flow could therefore not exist. In one case the axial component of velocity is constant, and in the other the product of axial velocity and density is constant. I should be most interested to have practical proof that there is any difference in efficiency between the two flows, and of Mr. Pochobradsky's categorical statement that no radial redistribution of gas can take place.

With regard to his remarks on efficiency, his figures are, of course, unassailable. There is some difficulty in comparing figures for a jet-propulsion turbine with a stationary power turbine, but it is probably better to consider η_{util} rather than η_{lost} as Mr. Pochobradsky has done.

The example that he has taken then becomes

$$\eta_{util} = \frac{85 + 20}{117 \cdot 7} = 89 \cdot 2 \text{ per cent.}$$

Yours faithfully,
J. H. C. ATKINS.

199, Beechwood-avenue,
Coventry.
July 9, 1947.

THE THERMODYNAMICS OF THE HEAT PUMP.

TO THE EDITOR OF ENGINEERING.

SIR,—In your issue of June 27, on page 552, you published a letter from Dr. Kestin on the subject of heat pumps which prompts me to write also on the same subject. It is apparent that some people view the heat pump with the same sort of suspicion as they accord to "perpetual-motion machines." It looks too much like a means of getting something for nothing—in fact, too good to be true. A childish simile may serve to dispel this idea. A man possessed of a horse and in need of meat can either kill the horse and eat it, *i.e.*, convert horse into meat, or he can use the horse to fetch meat from the butcher. A healthy horse could fetch many times its own weight of meat before it died of exhaustion. If for "horse" we substitute "horse-power" and for "meat" read "heat," we have two similar alternatives. A man possessed of horse-power and in need of heat can either convert his horse-power into heat or use it to bring in heat from outside. If he chooses the latter, he will use a heat pump.

Yours faithfully,
K. H. GRAY.

The British Internal Combustion Engine
Research Association,
112, Buckingham-avenue,
Slough, Bucks.
July 11, 1947.

CONSTRUCTION OF SEVERN BRIDGE.—In a written answer to Mr. P. Freeman in the House of Commons on Monday, July 14, the Minister of Transport (the Rt. Hon. A. Barnes) said that the main borings for the Severn Bridge had now been completed, both in the river and on land. Some subsidiary borings were in hand and would be finished in about a month or six weeks. The borings had established the fact that good foundations were available for both the main anchorages and the main piers; and it was hoped that contract drawings for the piers would be ready towards the end of this year. Construction would probably begin next spring and would occupy about five years.

THE INSTITUTION OF CIVIL ENGINEERS.

FOR many years, the annual conversazione of the Institution of Civil Engineers has been one of the principal events of the Institution's year, and its cessation during the war (to judge by the normal attendance) must have been regarded by a large part of the membership as a major deprivation. The decision of the Council to resume the function was correspondingly popular and drew a large concourse of members and guests to the Institution building in Great George-street, Westminster, on Thursday, July 10, to be received by the President, Sir William Halcrow. Subsequently, they were entertained with a violin recital by Miss Olive Zorian, who was accompanied on the piano by Mr. Norman Franklin, and a programme of music rendered by the orchestra of the Royal Artillery, conducted by Major O. W. Geary, M.B.E.; instructed on the subject of "Roman London" by Mr. W. F. Grimes, M.A., F.S.A., Director of the London Museum; and informed regarding the more modern manifestations of civil engineering by means of an exhibition of models and scientific apparatus, of which a description is given below. A topical touch was the inclusion in the exhibition of a number of photographs taken during the summer meeting on the North-East Coast (reported on page 39, *ante*).

The first exhibit was a model by Messrs. Vickers Limited of a cement works with Reflex kiln and air-swept pulverised-coal plant, designed for an output of 250,000 tons per annum. The Ark of Noah competition recently organised by the Worshipful Company of Shipwrights produced a series of models, to which reference was made on page 125 of our previous volume, and the first prize was won by a team of three employed by Messrs. J. Samuel White and Company, Limited, and the third prize by another team of three from the Tyne Dock Engineering Company, Limited, South Shields. These two models constituted the second exhibit. Mr. Brian H. Colquhoun, B.Sc., M.I.C.E., showed a model of the hangar, now under construction, which will accommodate the new Brabazon Mk. I aircraft during its erection at the works of the Bristol Aeroplane Company. The hangar consists of a centre bay and two outer bays, the overall width being 1,052 ft. The clear span of the roof trusses is 331 ft. and the height to the eaves is 83 ft. The floor area of the hangar will be 325,000 sq. ft.—about 7½ acres. The centre bay is too wide to be served by one overhead crane, but this difficulty will be overcome by arranging for the crane to pass from one travelling gantry to the next, the two gantries being placed in line to permit this.

Mr. A. W. Bishop, M.A., A.M.I.C.E., designed two types of apparatus, which were exhibited, for testing the shear strength of soils. The "shear box" has been developed since Alexander Collin's classic study of the stability of clay slopes in 1846, and Mr. Bishop's model, lent by Mr. A. W. Skempton, M.Sc., A.M.I.C.E., of the Imperial College of Science, was generally similar to the one described by Mr. H. Q. Golder in ENGINEERING, vol. 153, page 501 (1942). The method of applying the load ensures a constant rate of increase of strain. Most shear boxes are designed to test samples about 2½ in. square and ¾ in. thick, and are therefore unsuitable for testing gravels which contain stones up to 2 in. in size. Mr. Bishop designed a shear box to take samples 12 in. square and 6 in. thick, and it was made by the Metropolitan Water Board, whose Chief Engineer, Mr. H. F. Cronin, C.B.E., M.C., B.Sc., M.I.C.E., lent it for the exhibition. It has been used in connection with the design of large earth dams, and we understand that it is unique, in point of size, in this country. Tests have shown that well-graded sandy gravels may have an angle of internal friction of at least 45 deg.

The National Physical Laboratory, of which the Director is Sir Charles Darwin, K.B.E., M.C., exhibited several pieces of apparatus. One was a meter for measuring sub-surface velocity in hydraulic models. The meter, which was designed by Mr. L. E. Prosser and Mr. G. A. Y. Young, of the Engineering Division of the Laboratory, consists of a small vane, submerged to the desired depth, and mounted on a slender arm which was balanced, above the water, by an electronic device. The instrument was designed for use on the 20-ft. wide gantry spanning the River Forth model at the N.P.L., but, for convenience, was shown in use on a small tidal model. Several models designed to illustrate the instability of plates under compression or shear were also exhibited by the N.P.L. They show that buckling of plates does not, by itself, lead to immediate failure, although the stiffness of the structures is appreciably reduced. Models were also used to demonstrate that initial stability is improved by lateral curvature, but that the strength after buckling is not much altered. The compression flange of a bent beam is always liable to collapse as an Euler strut, and it is only prevented from doing so by the support afforded by the web. If the web is thin, or more especially if it is itself liable to buckle, the support afforded to the compression flange may be insufficient. General instability of this type was illustrated, and the method of stabilising a thin web by curving the beam so that the web is subjected to tension crosswise was also shown. One model was designed to show instability in a structure loaded in tension. The National Physical Laboratory also showed a model built in connection with Dr. Oscar Faber's design for the ventilation system for the debating chamber of the new House of Commons. The model was $\frac{1}{12}$-full size, and employed water, into which dye was injected to enable the flow to be observed.

Mr. A. L. Little, B.Sc. (Eng.), A.M.I.C.E., showed samples of sands and silts, together with their grading curves and notes on their engineering properties; and two models to demonstrate how conditions affect the effectiveness of sand as a foundation material. A rubber tube containing dry sand was normally quite soft and pliable, but when subjected to a vacuum it became hard and unyielding—the latter condition being comparable to dry sand confined by walls or surrounding ground and not free to move. The second model consisted of a glass cylinder containing sand which supported a model tower. When the tower was pressed by hand it was found to be quite firmly supported, but when water under slight pressure flowed up through the grains of sand, the sand lost its stability, and the tower toppled over. The phenomenon known as "piping," "blowing," or "boiling," was demonstrated by Mr. Little with a permeameter consisting of a vertical Perspex cylinder filled with sand, with points for measuring pressure at different levels. Water flowed upwards through the sand, and when the pressure of water was increased to a certain critical value, the sand suddenly became agitated, some of it being carried upwards by the water. This caused cavities in the body of the sand, and, these cavities being successively filled up by caving-in, the whole became unstable.

Electro-osmosis*—the movement of water in soil, produced by the passage of an electric current—was demonstrated on a small scale, using soil of very low permeability, by a model from the Road Research Laboratory, contributed by the Director, Dr. W. H. Glanville, C.B.E., M.I.C.E. The same laboratory also exhibited samples of soils which had been waterproofed by mixing-in small quantities of bituminous or resinous materials; and two model concrete road slabs to demonstrate "mud pumping," *i.e.*, mud being forced upwards through the joint line of the two slabs, whenever passing traffic presses down a slab, the foundation of which is weak.

An interesting process, related to electro-osmosis, was demonstrated by the Building Research Station, the Director of which is Dr. F. M. Lea, O.B.E., D.Sc., F.R.I.C. It showed the electro-chemical hardening of clays, and the particular feature of the process was the use of aluminium anodes. When a current is passed through the clay, the introduction of aluminium ions results in base exchange, which causes the clay around the anode to become harder. The practical applications of this process are being investigated, particularly in relation to the bearing capacity of friction piles in soft clays, and for stabilising clay slopes. Another exhibit from the Building Research Station was an apparatus for measuring strain at a remote point, where it is difficult to set up measuring apparatus, and a connection by cable to the strain gauge is impracticable. A vibrating-wire strain gauge, developed at the Building Research Station, was connected to a recording meter by a radio link.

Mr. F. M. Andrews, M.A., A.M.I.C.E., exhibited a model, to a scale of 1 in. to 1 ft., which was built in 1940 to test a new design of automatic sluice. It was designed for use in rivers, canals, or reservoirs, where it is desired that operation of the sluice gate, to maintain a predetermined level upstream independent of the level downstream, shall be entirely automatic, and achieved solely through the action of the water upstream. The gate is radial in form, with its hinge centre-line horizontal, and transverse to the channel. The counter-balancing and opening and closing of the gate, are effected by two cylindrical vessels, one on each side of the gate in a watertight chamber, the vessels being suspended from pulleys on a horizontal shaft by means of chains, and the gate being lifted by further chains and pulleys on the same shaft. The movement of the gate depends on the weight of the vessels, which is automatically varied according to the level of water upstream, by allowing water to flow into them from adjustable V-notch weirs on the upstream side through flexible pipes, and to flow out of them, over weirs in the vessels, to the downstream side. The opening movement of the gate is restricted—to prevent it opening widely every time the lifting moment of the vessels exceeded the weighing moment of the gate—by having the pulleys conical in shape, to vary the moments on the shaft as the chains were wound on or off.

A Braille transcribing machine was exhibited by Mr. M. du Plat-Taylor, M.I.C.E., on behalf of the National Institute for the Blind. The machine, which has a space-bar and six keys, each controlling a style, is electrically driven, and designed to emboss both halves of a folded sheet of zinc with Braille characters. A sheet of paper is printed on both sides by pressing it between the two halves of the folded zinc plate, and, so that the Braille characters on one side of the paper shall not interfere with the characters on the other side, they are "staggered." Up to 70 impressions per minute can be made. A Braille map-making machine, developed by the Technical Research Committee of the National Institute for the Blind, was also exhibited. A pointer is moved over the map which is being copied, and the zinc plate is caused to follow a corresponding path. A series of dots, the size and shape of which may be varied, is embossed by a die which is actuated by a solenoid. Even spacing between the dots is achieved by means of a thread, which unwinds as the carriage carrying the plate moves. The thread rotates a commutator which actuates the solenoid at regular intervals.

Mr. J. G. Thon, M.Sc., A.M.I.C.E., exhibited an instrument for measuring directly the tangent of an angle. It was developed especially for determining the tangent of a curve at any desired point, in connection with the differentiation of curves, and was widely used by Government Departments during the war. A selection of drawings and photographs of blast damage to framed buildings, caused by atomic bombs at Hiroshima and Nagasaki, was shown by the Ministry of Works, to which Sir Reginald Stradling, F.R.S., M.I.C.E., is Chief Scientific Adviser. Mr. C. H. Dobbie, B.Sc. (Eng.), M.I.C.E., showed a model of the sea-wall which is being constructed at Pett, near Rye, Sussex. It is a clay wall protected by concrete block-work, and with a berm (a Dutch practice) of local material coated with asphalt, to break up wave action. The Civil Engineer-in-Chief to the Admiralty, Sir Arthur Whitaker, K.C.B., M.Eng., M.I.C.E., lent a model of the naval sea-forts which were designed by Mr. G. A. Maunsell, B.Sc. (Eng.), M.I.C.E., for the protection of the Thames Estuary during the war. A model of a swashplate-type high-pressure oil pump, for pressures up to 3 tons per square inch was exhibited by Mr. T. E. Beacham, B.Sc., M.I.C.E.; and three topographical models prepared from air photographs were shown by Mr. P. G. Mott, B.A., A.M.I.C.E. The London Passenger Transport Board, the Chief Engineer of which is Mr. P. Croom-Johnson, M.I.C.E., lent a model of Charing-Cross Underground Station.

* See ENGINEERING, vol. 163, page 121 (1947).

THE INTERNATIONAL RAILWAY CONGRESS, LUCERNE.

(*Continued from page* 29.)

CONCLUSIONS ON SLEEPERS.

IN our two previous issues we have given the summary of the two reports on sleepers prepared by Mr. J. Van Rijn for the fourteenth session of the International Railway Congress Association, together with some additional information of interest extracted from the reports themselves. Mr. Van Rijn terminated his summary with eight conclusions, which it was the business of the delegates to discuss, amend as required, and adopt. These conclusions, as finally adopted, are given below.

1. "Of the various types of sleepers, the wood sleeper is still by far the most widely used. Soft and resinous woods are employed as well as hardwoods; the railway's choice of timber varies according to the resources of the country and economic circumstances. Each system has adopted dimensions and conditions of supply to meet its requirements; such dimensions and specifications do not differ very much as a general rule."

2. "After natural or artificial seasoning, it is desirable to impregnate wood sleepers by means of some antiseptic product, which prevents rot and appreciably lengthens their life. The most widely used and most effective product is tar-oil or creosote. It would be interesting to study more deeply substitute products for creosote. Impregnation should preferably take place in the railway shops at the same time as the sleepers are adzed and bored, as then the work is more likely to be properly done."

3. "The method used to fasten the rail to wood sleepers plays an important part in the conservation of the latter; mechanical wear of the sleeper, together with rot, is, in fact, the main cause of deterioration. On many railways, flat-bottom rails are laid directly on the sleepers and secured by means of spikes or coach-screws with good results; for lines with heavy traffic, or where there are small-radius curves, the use of sole-plates with direct fastenings, or, better still, indirect fastenings, is likely to prolong the life of the sleepers appreciably. Chairs have to be used with bull-head rails. The placing of pads made of special wood or preferably of rubber has produced interesting results on some systems."

4. "From the point of view of strength and life, metal sleepers can replace wood sleepers, except, of course, where track-circuiting is involved. They are preferable in tropical countries, where wood perishes very quickly. It would seem preferable to fasten the rails by means of sole-plates or chairs welded to the sleepers, rather than make use of direct fastenings with clips or spikes and bolts."

5. "Concrete sleepers are not yet widely used, though certain types made of ordinary reinforced-concrete have given quite good results; present research would seem to be concentrating on prestressed concrete. The fastening of the rail to concrete sleepers is still a difficult problem."

6. "The conservation of the sleepers depends to a large extent on the maintenance of the correct level of the track. This maintenance can be carried out either by tamping, by hand or mechanically, or by measured shovel packing. The latter gives excellent results, and is being more and more used. The repair of defective fastenings by the appropriate means is another essential factor for prolonging the life of sleepers; such repairs are usually made in conjunction with re-adzing, re-cutting the shoulders, and repairing any splits. Owing to the present shortage of labour, the use of mechanical methods for all maintenance work is to be greatly recommended."

7. "Maintenance of metal sleepers in the track is limited to tightening up the fastenings. Repairs to cracks by welding, and the replacement of sole-plates, can only be done when the sleepers are taken up. The only maintenance operation possible with concrete sleepers is the replacement of the fastenings."

8. "When its appreciably shorter life is taken into account, the softwood sleeper, in spite of its lower first cost, costs more per year of service than a hardwood sleeper. Although the information supplied by the different railways does not make it possible to say so definitely, it would appear that, leaving aside those countries rich in timber, the cost of impregnating sleepers is made good by their longer life. The use of metal sole-plates, especially with indirect fastenings, prolongs the life of wood sleepers, but the figures supplied do not make it possible to conclude that there is a definite economic advantage to be obtained thereby. The same applies to every device capable of reducing the hammering of the rail on the sleeper. In steel-producing countries, the metal sleeper may compete with the wood sleeper from the point of view of annual cost. It is not yet possible to give any definite opinion from a financial point of view concerning concrete sleepers, the price of manufacture of which is high. If they can be given a sufficiently long life by careful manufacture and a suitable method of fastening, their annual cost may become lower than that of wood or metal sleepers."

During the discussion prior to the adoption of these conclusions, Mr. T. W. Mundt, Chief Engineer of the Netherlands Railways, drew attention to two matters of interest which were not incorporated in the conclusions. In connection with the third conclusion, he referred to the corrosive action of creosote on rubber, which makes it preferable to use a pad of special wood; and with regard to the sixth conclusion, he said that it was useful to cover sleepers with ballast, particularly in hot countries, to protect them from the rays of the sun and prevent the wood splitting. Mr. W. K. Wallace, C.B.E., Chief Civil Engineer of the London Midland and Scottish Railway Company, said that his company had continued to use measured shovel packing throughout the war, and had no intention of giving up this practice. It provided adequate resilience and solidity.

REDUCING THE WEIGHT OF ROLLING-STOCK.

The reports on the reduction of the weight of rolling-stock were prepared by three engineers: Mr. E. A. W. Turbett, on behalf of English-speaking countries; Mr. R. Guignard, of the Swiss Federal Railways, for other countries; and Mr. W. A. Vrielynck, of the Belgian National Light Railways, on behalf of "light railways and colonial railways." It should be noted, however, that Mr. Turbett's and Mr. Guignard's reports covered some colonial railways. Mr. Guignard's report is very extensive and well illustrated, and constitutes a valuable account of the progress made in the reduction of weight of rolling-stock, especially in France, Switzerland and Sweden. The special report, summarising the three, for the benefit of the delegates to the Congress, was prepared by Mr. José de Aguinaga, of the National System of Spanish Railways, and our account is based on it, with some additional information from the three reports. The conclusions prepared by Mr. de Aguinaga, for discussion by the delegates, were formulated after considering 61 replies submitted by railways. The Association of American Railroads replied on behalf of many companies.

Until comparatively recently, the designers of rolling-stock concentrated on the provision of increased capacity, comfort (in passenger stock), and strength to suit increasing speeds; and, as a result the weight of vehicles rose, in many cases, to more than one ton per passenger. With the advent of road motor transport, however, the railways were obliged to economise by introducing lighter coaches and railcars, while still retaining, and improving, their high standards of speed, safety, and comfort.

CARRIAGE UNDERFRAMES AND BODIES.

Quite apart from the possible use of special steels and light alloys, a reduction in the weight of rolling-stock is effected by eliminating excess material, leaving every part, as far as possible, uniformly stressed. The traditional method of designing a coach, by providing a rigid underframe to absorb all tractive and buffing forces, with the body built on it, has therefore been abandoned by 90 per cent. of the railways concerned, in favour of a composite construction in which the body absorbs a proportion of the forces. The floor and side members may be designed for this function, or the roof, side, and floor members may form a tubular girder. Furthermore, the sheathing or plating of the body may be arranged to increase the strength of the vehicle. Most European countries have adopted these methods. The companies referred to in Mr. Guignard's report provide substantial reinforcements to the ends of the girder assembly, to carry the buffing and draw-gear fittings and resist the forces associated with them. In the United States, however, where the centre girder layout is used, horizontally-acting forces are almost wholly absorbed by the underframe. Thus, European designs are generally lighter in weight, but at the expense of some loss of resistance to horizontal forces. In the tubular girder form of construction, the shell is reinforced by providing transverse ribs in the form of hoops or rings, each rib stiffening the walls and roof, and providing a convenient position for the partitions for compartment-type carriages, or simply acting as reinforcement in the case of carriages without compartments. The distance between adjacent ribs, however, is too great to permit the wall plating to be left without further support or inherent strength, and there are three methods of overcoming this. Additional smaller ribs may be provided, or the moment of inertia of the plating may be increased, either by using corrugated plating (a method which is used in the United States), or by attaching flanged members inside the plating. The latter method has the advantage that it leaves the exterior surface smooth—for the sake of appearance and ease of cleaning.

The method of manufacture naturally depends, to some extent, on the size of the particular order and the facilities of the workshops. At the present time, most manufacturers are dealing with large orders which justify the provision of special tools, dies, etc., and facilitate mass-production methods, especially for pressed and stamped parts. It is also economical to use materials of special sections. In the construction of carriages, electric welding replaced riveting, as far as possible, some years ago. This was, in fact, indicated at the Cairo meeting of the Association in 1933. It is estimated that 90 per cent. of manufacturers now use welding instead of riveting, except where the metals used are difficult or impossible to weld. For this reason, the use of special steels is not always favoured. In some prototype designs in light alloys, rivets of the same material have been used for assembling the body, or cadmium-plated steel rivets have been employed to eliminate galvanic action between ferrous metals and aluminium and its alloys.

The general tendency in Europe is to use ordinary mild steel of about 25 tons per square inch tensile strength for rolled sections and pressed plates. Steel of slightly better quality, about 40 tons per square inch, is often used for the more important parts such as the headstocks, transverse members for bogie pivots, strengthening pieces at the ends of the underframes, and, sometimes, for the whole of the work. In the United States, nickel-chrome steels are used, and cast steel is employed for the headstocks and bogie-pivot transoms.

(*To be continued.*)

NEW SHIPBUILDING YARD FOR INDIA.—It is reported from Bombay that a new shipbuilding yard is to be established at Karachi at an estimated cost of 3,750,000*l.*, for the construction of ocean-going vessels of 10,000 to 15,000 tons. It is understood that land for the new yard has been leased by the Karachi Port Trust for 99 years, and that Messrs. John Brown and Company, Limited, Clydebank, have undertaken to provide technical assistance.

FINISHING PROCESSES FOR METAL.—The colouring of and protective coats for metals are dealt with in a publication entitled *Modern Finishes*, issued by Messrs. Metal Processes, Limited, 48, Frederick-street, Birmingham, 1. The operations described are mainly chemical and consist of immersion in baths, no electrical equipment being needed. The processes comprise that for giving a black finish to steel parts; an imitation nickel finish on brass, copper and other alloy parts; various coloured finishes on non-ferrous parts, including aluminium; rust-preventive dipping; and de-greasing treatment.

THE IRON AND STEEL INSTITUTE MEETING IN SWITZERLAND.

A SPECIAL summer meeting of the Iron and Steel Institute, now being held in Switzerland, opened with a reception, given by the Canton and Municipality of Zürich, on the evening of Wednesday, July 9, at the Kongresshaus, Zürich. In a speech of welcome, Dr. A. Lüchinger, Stadtpräsident of the City of Zürich, said that he hoped the visitors would find much to interest them in the industrial establishments of Zürich and the neighbouring towns. In the course of his reply, Dr. C. H. Desch, F.R.S., President of the Institute, emphasised the excellence of the products of Swiss industry.

The technical sessions of the meeting were held in the Auditorium Maximum of the Eidgenössische Technische Hochschule, the Swiss Federal Polytechnic, on the mornings of Thursday and Friday, July 10 and 11. At the opening session on July 10, Dr. Desch occupied the chair. Dr. A. Rohn, President of the Federal Polytechnic Council, who spoke in French, offered a cordial welcome to the Institute and said that, in holding their gatherings in the Polytechnic, the members were meeting, as it were, on the soil of the Swiss Confederation, since the Polytechnic was the only educational establishment for which the Swiss Government was responsible. In this way, the Confederation showed their interest in applied science. In Switzerland, primary, secondary and university education were the responsibility of the Cantons, which adopted the instruction given to the varied cultural and other requirements of the different parts of the country. Switzerland lacked natural resources and suffered from other disadvantages, but the fact was that these unfavourable economic conditions had obliged the country to make the best possible use of its intellectual resources and manual skill. The beauty of Switzerland and the eternal snows of her mountains (the source of her water-power) were practically her only natural resources and if her people were to maintain a high standard of living, they must do so by hard work. Switzerland was obliged to export a large part of the goods she produced and only 60 per cent. of her total production and 15 per cent. of her output of machinery were consumed within her borders. Those figures were lower than the corresponding figures for any other industrial country. Switzerland had to buy her raw materials abroad, and, the level of wages being high, Swiss exports were possible only because of the high quality of her products. It was the absence of raw materials which had made it necessary to produce goods of the highest quality. All Swiss educational establishments had had to adapt themselves to this necessity and to train both manual and intellectual employees to produce goods of very high quality. In the realm of applied science, this was the task of the Federal Polytechnic, which was called upon to train young engineers to apply their training in a way showing initiative and originality. During the past year, the Swiss Government had voted the sum of 27 million francs for the enlargement and development of the laboratories and research departments of the Polytechnic.

The President, after giving a summary, in English, of Dr. Rohn's address, thanked him for his share in the magnificent reception which the Institute was being given in Zürich. The relations between Great Britain and Switzerland, he added, had been of the friendliest and closest kind for very many years. These two countries held a common democratic tradition in which they had, to some extent, led the world.

PIG IRON AND STEEL PRODUCTION METHODS.

The first three papers to be discussed at the meeting, namely, "Electric Smelting" and "The Production of Iron and Steel with Oxygen-Enriched Blast," both by Professor R. Durrer, and "Possibilites for the Extended Use of Oxygen in the British Steel Industry," by Mr. M. W. Thring, were jointly discussed. In presenting his first paper, Professor Durrer stated that the development of the electric smelting furnace was based on two existing furnaces, namely, the blast furnace and the open electric furnace for the making of ferro-alloys. As only comparatively little gas rose from the hearth of an electric furnace, little heat was transferred from the hearth to the shaft, so that the temperature decreased quickly between the hearth and the shaft. It was so low in the latter that only little reduction took place there. The sensible heat of the gas, too, was correspondingly low; hence the shaft was not really necessary and could be dispensed with. Thus, the high-shaft furnace had become a low-shaft furnace in which the arch extended over the whole hearth. As already stated, the ferro-alloy furnace had also been used as a basis for the development of the electric smelting furnace, and to recover the valuable gas developed during the process, a cover was fitted on the furnace. The electric low-shaft furnace which had resulted from these developments was available in two designs, the Tysland-Hole furnace and the Siemens electro-smelting furnace. Their present capacity ranged up to 10,000 kW, but larger designs were now being planned. With a suitable burden, the energy consumption amounted to about 2,500 kWh per ton of pig iron, so that a 10,000-kW furnace could produce about 100 tons in 24 hours. On account of the small height of the charge, the low-shaft furnace permitted the use of inferior coal. Moreover, owing to the lower consumption of coal per ton of pig iron, less sulphur was introduced into the electric furnace, and this was one of the reasons why pig iron from the electric furnace had a lower sulphur content than that produced under corresponding conditions in the blast furnace.

In his second paper, Professor Durrer considered the possibility of using oxygen-enriched blast for iron-ore smelting and for steelmaking by the Bessemer process. He said that for each ton of coal used, about 4 tons of air were blown into a blast-furnace and 5 tons of gas passed out at the top of the furnace. As the oxygen content of the blast was increased, the amount of sensible heat contained in the gas became correspondingly smaller, and the temperature gradient of the rising gas greater. In ordinary blast-furnace practice, the top-gas temperature stood at several hundred deg. C. As the oxygen content was increased, the top-gas temperature decreased gradually, reaching its lower limit at about 100 deg. C. As much less heat was transmitted to the top of the furnace than was the case in the blast-furnace, the hearth temperature of the oxygen furnace was much higher. If oxygen-enriched blast were used in the Bessemer converter, so much heat would be generated, as compared with atmospheric oxygen, that about half a ton of scrap could be melted down per ton of iron blown. A further development consisted in having a combined smelting-converting process, involving the addition of iron oxides, and, if necessary, coal. A process for the direct production of steel, which could be finished in an electric furnace, would result. Considerable technical and economic, but not fundamental, difficulties would have to be solved before the proposed methods could be made commercially practicable.

Mr. Thring, in presenting his paper on "The Possibilities for the Extended Use of Oxygen in the British Iron and Steel Industry," stated that it was clear that recent developments in methods of manufacturing oxygen, both in the range of purity 80 to 100 per cent. and in the range 40 to 60 per cent., made its use for the combustion of fuel in the steel industry a very important practical possibility. Oxygen could be used in the iron and steel industry on a large scale, in two ways. One was equivalent to a small percentage reduction of the nitrogen heated in the combustion process by mixing the oxygen-enriched air with the remainder of the combustion air. The other way made separate use of a small quantity of oxygen-enriched air. In the former category came the use of oxygen in the blast-furnace and in the Bessemer converter. The use of oxygen in the open-hearth furnace came into the second category, since this development was only of interest if the use of the oxygen was confined to the "critical period" of the melt and the oxygen-enriched air was introduced not with the main air stream, but in such a manner that it gave greatly improved mixing and combustion conditions.

Mr. R. Mather, who opened the discussion, stated that Professor Durrer had given some idea of the reasons why one would expect ultimately to find a definite advantage in the use of oxygen in the blast furnace. This would probably be one of the ways in which blast-furnace practice would develop, on steady and more or less expected lines; because the introduction of a higher percentage of oxygen in the blast was a fairly logical, and not a very revolutionary, step. Those with long memories could recall that 35 or 40 years ago there had been persons who had proposed new methods of manufacturing iron and steel from the ore which completely avoided the blast-furnace. Millions of pounds had been spent in nearly all the industrial countries of the world in that direction, but little or no appreciable progress had been made on those lines. On the other hand, it was probable that in the next 10 or 20 years positive developments would take place in the use of oxygen in connection with the existing type of blast-furnace. Moreover, there was no reason why these developments should not be confined with other developments in blast-furnace practice, such, for example, as the use of high top pressures, about which information, based on actual operating practice, was beginning to be received. Mr. Tring had referred to the difficulty of getting an organisation or firm to start using oxygen on a substantial scale. When in America, some twelve months previously, he had seen a very large oxygen plant being built at one of the large American steelworks. It was nearing the stage when it would be ready for operation. It had been suggested that it might be possible to utilise, for the production of that oxygen, the waste heat or energy of the iron and steel plant, but he doubted whether there were many integrated plants which had waste heat available for this additional operation. Nevertheless, even if there were no waste heat or energy which could be utilised for the separation of oxygen from the air and for the enrichment of the blast, it might still be a worthwhile operation.

Mr. Thring had pointed out that the use of oxygen in the steelmaking process would have considerable advantages in three or four directions, in so far as the Bessemer process was concerned. One other point would be the possibility of using the Bessemer process for pig irons of composition intermediate between the only two ranges of composition for which that process could now be used, namely, the low-phosphorus hematite-making acid-Bessemer process, and the high-phosphorus pig-iron of 1·7 per cent. and over basic-Bessemer process. One reason for that limitation, in so far as the basic Bessemer process was concerned, was that, with the intermediate phosphorus contents of 0·7 to 1·0 per cent., there was not enough heat available, but with oxygen in the blast it would be possible to obtain a hotter metal. One feature of Dr. Durrer's papers had been found puzzling. This was that it had been stated that the coal consumption in the existing blast-furnace was estimated to be 800 kg. per ton of iron. He wondered whether, in fact, it was not the carbon consumption which was being referred to since coal, as coal, was not used in the blast furnace. Again, in the paper on electric smelting, the word "coal" was used sometimes for carbon, sometimes for coal and sometimes for coke.

Mr. E. C. Evans said that oxygen enrichment was not a new conception. Upwards of 12 years ago, the Blast-Furnace Committee of the British Iron and Steel Federation had issued a report on the possibilities of oxygen in blast-furnace practice. The conclusion to which they had come at the time was that it would not pay in Great Britain for pig-iron production, but that it would pay for ferro-manganese or special-alloy production. That conclusion had been based on the price of coke at the time and the costs of oxygen from the plants then working. At present, the position had entirely changed. Coke costs had increased considerably, while, on the other hand, recent developments had appreciably reduced the cost of oxygen. Mr. Thring had referred to an expenditure of half a million pounds to test whether oxygen was any use in the blast-furnace. Largely as a result of a paper (which some would severely criticise) by Dr. I. Langmuir, written following a visit paid to Russia, American steel men had taken up the idea of oxygen enrichment with enthusiasm. Most of the large plants

in the United States were now testing out the use of oxygen in their open-hearth furnaces. With oil as the fuel, almost any modification of the oil burner to allow the introduction of oxygen produced useful results, and adding the oxygenated air during the melting-down period, they had been able to increase production by something like 30 per cent. with no greater wear on the refractories.

One works which had introduced oxygen into the bath as well as into the combustion air, had reduced the time of melting from tap to tap, from 11 to 11½ hours to a little over 6 hours, a truly tremendous increase in output. In that way, there were possibilities of using methods for producing oxygen which would not involve the very big plants needed for a blast-furnace. The amount of oxygen which had been used economically in the open-hearth furnace was of the order of 800 cub. ft. per ton of steel, which meant an oxygen plant of not unreasonable size. There were schemes in hand, however, for very large oxygen plants, and 500 tons a day was regarded as a reasonable size for one unit. Plants of that kind were being designed. All these big plants depended on a low-pressure liquefaction cycle. Kapitza had started this when, in 1941, he had produced oxygen with an initial pressure of a little over 80 lb., the air being passed through a specially-designed turbine running at an efficiency of 80 per cent. and upwards. This meant that oxygen could be produced at a capital cost lower than was formerly the case, in plants which could be operated by ordinary mechanics, not requiring a special technique, and with a power cost of the same order as, if not less than, that of the older systems.

Dr. M. Tigerschiöld agreed with Mr. Evans that it was now possible to produce oxygen cheaply and in large quantities. In a works producing non-ferrous metals at Trail, in Canada, large-scale experiments had been carried out using oxygen and steam in a gas producer fitted with a revolving grate. From an ordinary coal, a gas of 2,500 calories per cubic metre was quite easy to produce. The next speaker, Dr. L. Jenicek, congratulated Dr. Durrer on the perseverance with which he advocated the use of oxygen in the blast-furnace, and especially in the low-shaft furnace. It was impossible, however, to predict the value of Dr. Durrer's conception without practical proof. In 1940, Dr. Durrer had estimated that the direct reduction of iron ore in the low-shaft oxygen furnace would consume about 1,500 kg. of coke per ton of iron, but had regarded this consumption as an advantage because of the resultant production of gas of high quality in great quantity. Dr. Durrer considered his low-shaft oxygen furnace as an installation which would produce a rich gas with an inferior fuel. A problem which was not clear was that of desulphurisation in the low-shaft furnace. Dr. Durrer had said that provided the top gas temperature was sufficiently high, desulphurisation took place without special slag control—that no lime-bearing slag was needed and hence that the choice of raw materials for smelting was much extensive. This signified the attractive possibility of reducing poor ores with an acid slag. The most important factor in deciding whether oxygen could be used on a large scale was the price of the gas. In Czechoslovakia, a cubic metre of pure oxygen cost ½d. This was not cheap, but it was cheap enough to enable a good town gas to be produced from lignite. Construction costs of the plants, however, were not low.

(To be continued)

COUNTING CONTROL BY PHOTO-ELECTRIC CELLS.—A friction-driven counter is used in the Leicester factory of Messrs. Wolsey, Limited, to measure the amount of fabric passing over the steam-heated rollers of a calendar. The measurements can, however, be falsified by pressing on the drive and thus causing yardage to be recorded when no fabric is passing. To prevent this, a small lamp projector and photo-cell unit has been installed by the General Electric Company, Limited, Magnet House, Kingsway, London, W.C.2. Normally the beam of light from this projector is prevented from reaching the photo cell by the fabric and the counter operates as before. When no fabric is passing, however, light falls on the photo cell and, by means of an amplifier and relay, operates a trip switch on the counter so that counting stops. A guard is provided to prevent the photo cell from being obscured except by the fabric.

LABOUR NOTES.

ADDRESSING the Mineworkers conference at Rothesay, on its opening day, Mr. Lawther, the president, declared that unofficial strikes were "a crime against our own people." The time had come, he said, for very plain speaking on the matter. No stoppages could be justified, having regard to the present dire need for coal. There were now no opposing sides in the industry. All engaged therein must realise that the isolation of the past was no more.

During the discussion which followed the presidential address, Mr. Horner, the general secretary, reminded delegates that the Coal Board had been in control for only six months. He promised them that, in due course, there would be revision of the existing conciliation machinery, but it had to be borne in mind, he pointed out, that the Board was fundamentally a buyer of labour and the union a seller, and that between buyer and seller there were naturally differing points of view. Nationalisation had not changed that fact, and it had to be recognised. The conference left it to the executive to try to devise methods for speeding up conciliation machinery.

Wages were discussed at a private session of the conference on Tuesday. Delegates instructed the executive "as an interim measure" to press for "a substantial increase" forthwith in the minimum rates of all workers in the coalfields, aged over 18 years. The decision indicates that the miners are not prepared to wait for increased wages until the new wage structure, which the union desires, comes into operation on January 1. The Coal Board, it is understood, has agreed to negotiate on the subject of an interim increase without prejudice to the long-term negotiations for the new national wage structure.

There were strong demands at this session that all payments for tools and equipment should be done away with, and Mr. Horner stated that the Coal Board was already carrying out a survey to discover what it would cost to provide free tools and equipment. Copies of Lord Hyndley's letter intimating that unofficial strikers might be prosecuted for breach of contract, were circulated to delegates, and a discussion took place on its contents. A communication issued afterwards, was to the effect that no vote was taken and that the letter would be discussed by the delegates with their branches on their return.

Lord Hyndley, addressing the conference on Wednesday, said: "We looked to full and fair work on five days a week. Where restricted practices existed they were to be removed. We looked for the support and goodwill of the men to ensure rapid re-organisation so that this full and fair day's work could be assessed. This essential process has barely started. The resulting delay is intolerable. It means that the five-day week agreement is not yet being fully honoured. It means that the country is being kept waiting for the coal it has a right to expect."

Attendances at work, which re-acted favourably to the five-day week when it was first introduced, Lord Hyndley went on to say, had deteriorated. Fewer men were now working the number of shifts they worked in May. The result was that output had fallen. The current weekly rate was about 100,000 tons less than in the weeks following the introduction of the five-day week. We were failing to justify the five-day week as a reasonable reform under existing circumstances.

Mr. Lawther said that nobody was more sick than the union was of the unofficial strikes and of the people who "provide the most absurd and ridiculous alibis for their conduct. We say to you and your colleagues on the Board," he added, "Go ahead and take whatever action you believe is essential to meet the position. We are confident that you have the wholehearted support of the great mass of our membership."

Mr. Shinwell, Minister of Fuel and Power, who addressed the conference on Thursday, said that 10 per cent. of the miners were not pulling their weight. "Let them look out," he declared. "We cannot afford to stand any more nonsense. I plead with them to play the game. A pit or two might have to be closed if the men continued to hold the nation to ransom." He sometimes doubted, he added, that he had had the full co-operation of some of the miners' leaders on a lower level—men responsible for the conduct of affairs in lodges and branches of the union.

The National Coal Board stated, on Thursday last week, that the total coal production in Lancashire, Cheshire and North Wales in June was 1,077,243 tons—171,761 tons short of the revised target. Every area in the region had failed to reach its target. Output in Durham, Northumberland and Cumberland was 3,132,127 tons—138,747 tons up compared with the total for May when output was low because of holidays and a strike. South Wales miners just failed to reach the weekly target of 500,000 tons throughout June. In four weeks they raised 1,963,834 tons.

At Geneva, on Friday last, the International Labour Conference adopted a resolution recognising the right of employers and workers to organise without official interference, the right to affiliate with international organisations, and the right to protect the workers from discrimination arising from trade-union membership. The decision is to be embodied in a proposed convention to be discussed at next year's conference.

The Ministry of Labour and National Service states that the changes in rates of wages reported to have come into operation in the United Kingdom during May, resulted in an aggregate increase estimated at approximately 55,500*l.* in the weekly full-time wages of about 200,000 workpeople, and in a decrease of about 4,500*l.* in the wages of about 195,000 workers. In addition, a number of workpeople had their hourly rates increased, or were granted a bonus so as to give approximately the same weekly wages as before for a shorter working week. In the first five months of 1947, 1,171,500 workpeople received increases in weekly wages estimated at 283,500*l.*

The principal groups of workpeople affected in May by increases in rates of wages, were employed in the laundry trade, in seed crushing, compound food and provender manufacture, and as shift workers in the gas industry. In Scotland, there were increases for workpeople employed in milk distribution and for apprentices in the building industry. The industries in which wage rates were decreased during May included pig-iron and iron and steel manufacture, iron-ore mining, and limestone quarrying in certain districts, and tobacco manufacturing. The reductions were due to arrangements under which wages fluctuate according to movements in the cost-of-living index figure. Of the total increase in May of 55,500*l.*, about 35,000*l.* was the result of orders made under the Wages Councils Acts, about 9,000*l.* resulted from arbitration awards, and the remainder was the result of arrangements made by Joint Industrial Councils, or other joint standing bodies established by voluntary agreements, or of direct negotiations between employers and workpeople or their representatives.

The changes in hours of labour reported to the Ministry in May resulted in an average reduction of about 5 hours a week for about 910,000 workers. The principal industry affected was coal-mining, in which the normal working week for underground workers, which previously varied according to district, was reduced to five consecutive shifts of 7¼ hours each, plus one winding time, while the hours of surface workers, who normally worked 44 to 49 hours, according to district, were reduced to 42½ hours, exclusive of meal times, to be worked in five consecutive shifts of 8½ hours. In the gas industry, the normal working week, for workers other than shift workers, was reduced from 47 to 44 hours. In the paint, varnish and lacquer manufacturing industry, normal weekly hours were reduced from 47 to 44.

The number of industrial disputes, involving stoppages of work in the United Kingdom reported to the Department as beginning in May, was 100. In addition, 24 stoppages which began before May were still in progress at the beginning of that month. The approximate number of workers involved, during May, in these 124 stoppages, including workers thrown out of employment at the establishments concerned, although not themselves parties to the disputes, is estimated at about 70,000. The aggregate number of working days lost during May was about 181,000. Of the stoppages in May, the coal-mining industry accounted for 61, involving over 43,000 workers and resulting in an aggregate loss of about 99,000 working days.

Of the 100 stoppages which began in May, nine, directly involving 1,200 workers, arose out of demands for advances in wages; 31, directly involving 6,200 workers, arose out of other wage questions; 16, directly involving 7,800 workers, arose out of questions as to working hours; 11, directly involving 2,000 workers, arose out of questions respecting the employment of particular classes or persons; 30, directly involving 2,100 workers, arose out of other questions respecting working arrangements; and 3, directly involving 800 workers, arose out of questions of trade-union principle.

NEW METALS FOR OLD.*

By SIR EDWARD APPLETON, G.B.E., K.C.B., F.R.S.

IT is always interesting, and often stimulating, to look back and see the path of the developments which lies behind us. That is why I have chosen as the title of this lecture "New Metals for Old." I want, if I can, to show you how, during the last fifty years, many metals and, particularly, combinations of metals, have taken the place of others in the manufacture of things that people require and use. Progress in this respect has followed largely as a result of scientific developments though, in this subject of metallurgy, it is not unpleasant to have to admit that empiricism, now and again, has scored enormous successes.

It is important to note that many of the properties of alloys are not wholly determined by their chemical composition, but by the fine details of their interior structure invisible to the unaided eye. In the investigation of that structure the metallurgist uses many tools such as the optical microscope, X-ray diffraction apparatus and the electron microscope. I might mention briefly here the electron microscope, which is one of the latest weapons which science has put at the disposal of the metallurgist. Its operation depends on the fact that electric and magnetic fields can be made to act on an electron beam in somewhat the same way as glass lenses do on a light beam. Ordinary visual microscopes cannot be used on metals effectively at magnifications over about 3,000, nor can they give any detail about structures less than the wavelength of light in size. By using high-speed electrons, however, which behave as if they were waves of extremely small wavelength, and suitable electric and magnetic lenses, we can focus the electrons transmitted through any object on to a photographic plate. Since metals are opaque to electrons except as very thin films, the structure of metals is investigated by making a replica of the etched surface of a metal by means of a thin film of Formvar† or silica obtained by an evaporation technique. The film is then stripped off and examined in the electron microscope. Under the most favourable conditions of shape and size, objects of the order of one hundred millionth of an inch in size should be capable of being observed. This size is comparable with the dimensions of molecules of somewhat complex organic compounds.

An important victory in the war against corrosion was the introduction by Brearley of chromium stainless steel. Later, the 18 per cent. chromium, 8 per cent. nickel type and other austenitic high-chromium steels were produced. The latter were destined also to form the basis of many heat-resisting, *i.e.*, non-oxidising, steels which have been developed in recent years. The cost of these steels, on account of the high cost of alloying elements and the relatively high cost of fabrication, are factors which, at present, limit their application. The effectiveness of the chromium in these steels is due to the fact that chromium oxidises very rapidly. A film of chromic oxide is thus formed which is very tenacious and continuous; and it is this film which effectively stops further oxidation. If the surface of the steel is scratched, the protecting film is immediately renewed from below. Dr. W. H. J. Vernon, at the Chemical Research Laboratory of the D.S.I.R., has succeeded in detaching specimens of the actual films which were found to be about 100 Ångstrom units thick, shall we say one millionth of a centimetre, or perhaps 1/2000th or so of the thickness of a piece of cigarette paper. Films of zinc, cadmium, lead and aluminium applied by very diverse methods are also used to reduce corrosion.

The Corrosion Research Committee of the Iron and Steel Research Council, now remodelled as the British Iron and Steel Research Association, have carried out atmospheric corrosion experiments by exposing standard test specimens to the atmosphere in many parts of the world. The rate of corrosion of unpainted mild steel in a large industrial town is estimated at 2·7 thousandths of an inch per annum, whereas at a small town in mid-Wales the corrosion rate is about one-quarter of this value. The effects of atmospheric conditions on the rusting of iron have also been tested in the Chemical Research Laboratory by Vernon. He examined the attack in air in the absence of contamination, and then in SO_2, and also in SO_2 + ammonium-sulphate. The effect of these two reagents was found to be additive. It was noticed that on dusting the surface with charcoal, the SO_2 had a markedly increased corrosion rate.

Corrosion of the brass tubes in the condensers of steam-driven ships, particularly in battleships, was a source of great trouble in the first world war. In the recent war, largely as a result of the researches of the British Non-Ferrous Metals Research Association, the condenser tube trouble almost disappeared in spite of the more arduous conditions which modern steam-raising practices impose. Between the two wars, alloys had been developed consisting of either an addition of 1 to 1½ per cent. of aluminium to the 70/30 brass, or of a cupro-nickel alloy containing copper 70 per cent. to nickel 30 per cent. with the deliberate addition of 0·5 per cent. iron. Mr. Winston Churchill testified to the corrosion-resistant properties of these new alloys in the House of Commons in 1940 when, speaking of our warships, he referred to the trustworthiness of their engines and the absence of "condenseritis" so that "now they seem to steam on almost for ever."

One of the reasons why we use metals is that they resist deformation under stress or tension. One of the important problems facing the theoretical physicist is that of explaining why metals break, or in its converse form, why metals hold together. Sir Isaac Newton set this problem more than two hundred years ago, for in his treatise on optics he wrote "the parts of all homogeneal hard bodies which fully touch one another stick together very strongly. . . . There are therefore agents in Nature able to make the particles of bodies stick together by very strong attractions. And it is the business of natural philosophy to find them out." I must say, however, that this problem has proved a most difficult one, and we have not yet got a theory of cohesion, the predictions of which agree with experience.

Much of the work of both theoretical and experimental investigators of the theory of the metallic state has been concerned with finding out and accounting for the behaviour of single crystals under various stresses. Estimates of the strengths of single crystals of metals can be made by a number of theoretical methods, but the values obtained are always greatly in excess of those found in practice. According to calculation the maximum shear stress for a copper single crystal should be about 400 tons per square inch, whereas the ordinary polycrystalline form of the metal has a yield stress of about 6 tons per square inch, while single crystals of copper undergo plastic deformation under stresses as low as 0·1 ton per square inch. A single crystal of copper in the form of a rod one half of an inch in diameter can be bent in the hand easily to form a semi-circle. During this operation the resistance to bending noticeably increases, and it requires very considerable force to bend it straight again.

Recent developments of metallurgical science show that high tensile strength is not readily attained in simple metallic states. We get it, in fact, in atomic arrangements which are markedly distorted. Such conditions are brought about by cold working, alloying, age-hardening, or quench-hardening. In order to explain the fact that real single crystals are far weaker than the ideal single crystals imagined by the theoretical physicist, it has been suggested that no real single crystals are ever perfect over other than very limited regions. It has been suggested that there are in crystals numerous small faults where the crystal structure has got out of joint or out of step. A two-dimensional analogy is that instead of a row of atoms being directly opposite another row of atoms, one of the rows has one atom too many. It is suggested that sliding of one plane in the crystal over another is due to the progressive movement of the dislocations step by step across the crystal. This produces the same effect as simultaneous sliding of the whole plane, although at any one moment only a relatively small number of atoms are moving, and in consequence, the force required to produce shear is seen to be much less than would be necessary if the crystal were really perfect.

This brings us to the problem of why polycrystalline crystals are so much stronger than single crystals. It seems as if the extra strength of the polycrystalline material must be due in some way to the boundaries between the crystals. At these boundaries the atomic arrangement must be disturbed over a region a few atoms thick, so that when yield occurs in a crystal and a dislocation arrives at a crystal boundary it is unable to cross the disturbed region and is dissipated. An initial internal slip in a small crystal in a polycrystalline material is thus seen to be confined to the crystal in which it started, and unless such slips occur in many crystals simultaneously no plastic yield takes place in the material as a whole.

On this theory it follows that if the number of crystals per unit volume is increased, either by the effect of cold working or by the introduction of alien atoms between the crystals, *i.e.*, by the formation of an alloy, the propagation of dislocations is impeded, and this means that the metal becomes stronger. As my friend Professor Andrade puts it, "when a woman makes a cut in the edge of a piece of cloth and tears it, the tear will only run so long as the cloth is uniform; it will be stopped by a button hole or a join between two pieces of cloth. In particular, you cannot tear a patchwork quilt in that way."

After this brief excursion into theoretical physics, let us return to something more practical. The national problems before us to-day are the efficient use of coal and the generation of electricity. These problems are limited in the efficient design of the steam-raising plant. The achievement of increased efficiency depends on the use of higher temperatures and higher pressures, and this, in turn, demands new materials which can stand up to the new exacting requirements. Thanks to the new materials which the metallurgist has produced, the efficiency of large electrical generators increased by more than 65 per cent. in the 15 years before the war, and progress is still being made.

One of the difficulties of using metals at high temperatures under prolonged stress is their liability to flow or creep and so change their dimensions. Much attention has been given to this phenomenon at the National Physical Laboratory and elsewhere. The subject has been of particular importance in connection with the development of gas turbines for aeroplane propulsion, in which materials are subject to very great prolonged stress at very high temperatures. Creep is largely influenced by grain size. As the grain size diminishes the creep rate decreases to a minimum, after which, further decrease in grain size leads to increase in creep rate. Although the effect of grain size can be readily noted in the case of the metal tin, the phenomena accompanying creep in other metals are exceedingly complex and the effect of grain size is sometimes obscured by other factors, such as the initial degree of cold work and the rate of cooling of the metal. During the war, the development of materials for high-temperature service in gas-turbine blading has been actively pursued by several organisations in this country and various materials, the majority of which can be regarded as special steels, have been developed.

I now turn to say a word or two about metals required in the electrical and electronics industries. When I was a student at the University we had what was thought to be a fairly satisfactory theory of the process of electrical conduction in metals. According to this theory, which was due to Drude, the conduction of electricity along a wire was due to the slow drift of free electrons, the atoms of the conductor remaining fixed. But, as time has gone on, many facts have been disclosed which the old theory has failed to explain. In particular, it has been realised that the old theory gave completely wrong values for the specific heats of metals. But in recent years a new theory of metals, due in the first instance to Fermi, Dirac and Sommerfeld, has been developed, which is capable of explaining most of the outstanding phenomena. Meanwhile, our practical knowledge of the electrical properties of metals has been similarly expanding.

Now copper in the pure state is very largely used in the electrical industry on account of its high electrical conductivity. When used as overhead cable in long spans the cable must not only have high electrical conductivity but must have considerable strength to support its own weight and stresses due to wind or ice formation. Increase in strength can easily be obtained by alloying with another metal, but any substantial increase in strength is generally accompanied by a serious decrease in conductivity. If, however, cadmium is used as the alloying element it is possible, by adding 0·9 per cent., to obtain a very substantial increase in strength with only 10 per cent. reduction in conductivity. This alloy is used for trolley wires and for carrying the grid across the Thames at Dagenham. In the form of light cables it has been used extensively for communication purposes during the war, particularly during the various landings and also by parachutists in the desert and Burma, where it came to be known as "tree wire."

(To be continued.)

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* Tenth Edward Williams Lecture, delivered on June 18, 1947, at the 44th Annual Conference of the Institute of British Foundrymen, Nottingham. Abridged.

† Synthetic Resin, Polyvinyl Formal, Shawinigan, Limited.

JOINT INDUSTRIAL COUNCIL FOR THE DREDGING INDUSTRY.—The first meeting of the newly-formed National Joint Industrial Council for the Dredging Industry was held in London on Tuesday, July 8, when, the constitution having been duly adopted, Mr. C. C. Gover, chairman of the Federation of Dredging Contractors, was appointed chairman, and Mr. A. Bird, secretary of the Transport and General Workers Union, vice-chairman. Proposals for a new national agreement for the industry were also considered.

EMERGENCY POWER PLANT FOR SPAIN.—A Petter-Brush Diesel generating set has recently been installed in the new factory of Tarabusi S.A., on the outskirts of Bilbao, to provide power when the local electricity supply fails. The set comprises a super-scavenge two-cylinder vertical two-stroke engine with an output of 160 b.h.p. at 500 r.p.m. This engine is directly coupled to a three-phase alternator with an output of 131·25 kVA at a power factor of 0·8, a voltage of 230 and a frequency of 50 cycles per sec. The factory produces aluminium pistons of the Borgo type for internal-combustion engines.

EXPERIMENTS ON SIDE LAUNCHING.

Fig. 1. SIDE LAUNCH WITH FIXED WAYS & DROP OFF"

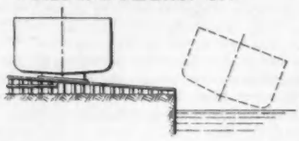


Fig. 2. SIDE LAUNCH WITH TILTING WAYS & DROP OFF"

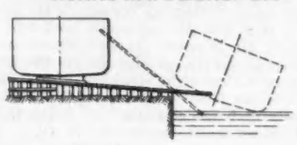
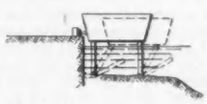
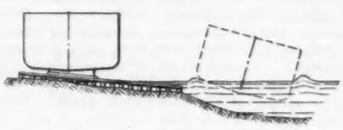


Fig. 3. SIDE LAUNCH. VESSEL BUILT ON PILES



(9080.A)

Fig. 4. SIDE LAUNCH. FIXED WAYS BUILT OUT UNDER WATER



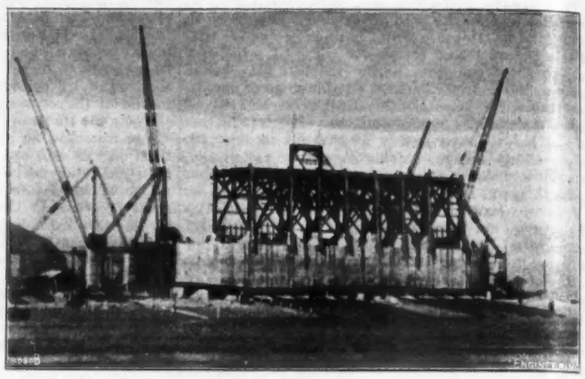
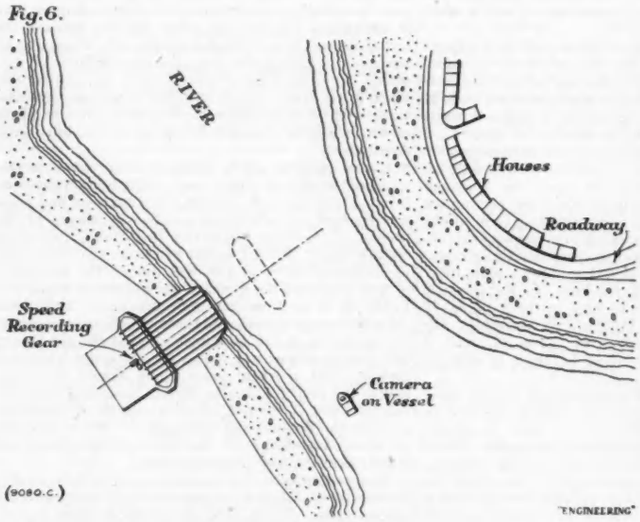


FIG. 5.

Fig. 6.



(9080.C.)

"ENGINEERING"

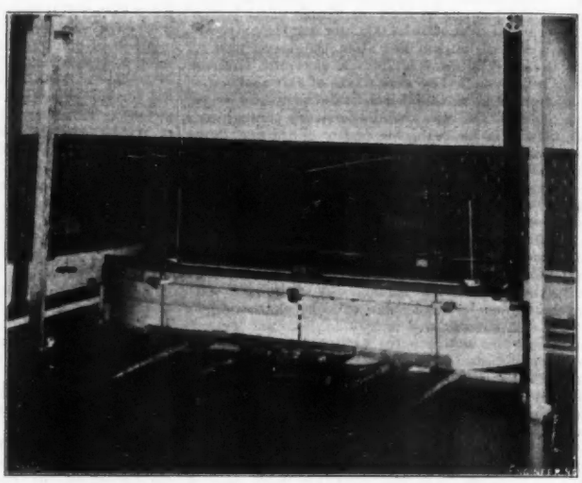


FIG. 7.

MODEL AND FULL-SCALE EXPERIMENTS ON SIDE LAUNCHING.*

By F. H. TODD, B.Sc., Ph.D., and E. LAWS.

SIDE launching is usually, although not always, adopted in place of end launching because of lack of water space. In end launching, the ship usually enters the water at considerable speed, since the run is long and the water resistance relatively small. Although there must be sufficient water space, it is usually not unlimited, and one of the problems is to arrest the motion of the ship. The chief danger in such a launch is the possibility of structural damage due to tipping about the way ends. In side launching, the run is normally short, and the high water resistance experienced by the ship when in the water and moving sideways rapidly stops the motion, so that no drags or anchors are necessary as a rule. The chief dangers are of structural damage due to the drop from the quay edge, from shipping water on the outward roll, or from the side of the ship hitting the quay on the reverse roll.

Four methods of side launching have been used, and are illustrated in Figs. 1 to 4, herewith. With fixed ways (Fig. 1), the standing ways reach just to the quay edge, and are fixed right up to their ends. The ship pivots about the way ends and drops off into the water at a considerable angle to the vertical—perhaps 45 deg. This method is commonly used in this country for launching barges, tugs and trawlers into canals or narrow rivers. With tilting ways (Fig. 2), the last length of the standing ways is allowed to tilt, so that the transference of the ship to the water is eased. This method is used in America for Great Lakes vessels and other craft. The third method was used in the case of certain concrete barges which were built alongside a quay on concrete piles, resting on the river bed. When a barge was complete, hand jacks were used to move her slowly outwards. The piles finally overbalanced (Fig. 3) and the barge dropped vertically into the water with no further outward movement. Fixed ways built right out under the water (Fig. 4) have not been used very much in the past, but this method was adopted in both the cases described in this paper. Under this condition, the vessel experiences a very high resistance when she reaches the water. The problem is rather to keep her moving long enough to float off the ways than of arresting her motion. If this can be done successfully, it obviates any risk of damage during the launch. A number of papers have been read in the United States on the subject of side launching; some of the more important statistics are given in Table I, herewith.

A large concrete pontoon, some 200 ft. in length, was

* Paper read before the North-East Coast Institution of Engineers and Shipbuilders at Newcastle-on-Tyne on April 28, 1947. Abridged.

TABLE I.—TYPICAL SIDE-LAUNCHING PRACTICE.

Ship.	Length, Ft.	Displacement, Tons.	Grease Pressure, Tons per Sq. Ft.	Run to Dock Edge, Ft.	Speed at Dock Edge, Ft. per Sec.	Coefficient of Friction.	G.M. Ft.	Declivity, In. per Ft.	Drop Off, In.	Heel, Deg.
Submarine	300	938	1·78	32	—	0·04	1·27	1 1/8	3 1/4	48
Cargo Vessel ..	—	2,465	2·61	50	—	0·031	—	1 1/4	13 1/4	—
Cargo Vessel ..	—	2,565	2·72	50	—	—	—	1 1/4	30	—
Minesweeper ..	—	351	2·25	28 ft. 6 in.	—	—	—	1 1/8	13	—
Destroyer	—	1,330	2·50	46 ft. 6 in.	—	0·020	—	1 1/8	3	—
Pierhead Pontoon	80	740	1·75	189	13 1/4	0·029	37·2	3/8	Nil	—
Concrete Pontoon ..	202	3,155	2·34	91	19 1/2	0·03	2·8	1 1/4	Nil	12

TABLE II.—LAUNCHING SPEEDS AND OTHER DATA FOR 26-FT. AND 24-FT. TIDES.

Tide Height in Feet Above Site Datum.	Speed in Ft. per Sec. when :—				Travel from Rest Until Maximum Speed is Reached.	Minimum Freeboard from Deck to Top of Wave During Launch.
	First Bilge Touches Water.	Speed is a Maximum.	Centre Line of Pontoon Passes Way Ends.	Pontoon has Travelled 220 ft.		
26 ft.	14·55	16·78			104·0	About 4 ft.
	15·92	17·80	9·4 to 9·8	4·25	95·0	" "
	17·44	18·30			92·0	Just less than 4 ft.
	18·32	19·14			88·0	About 3·5 ft.
	19·68	20·13			86·0	" "
	22·00	22·80			85·0	" "
24 ft.	18·33	20·13			112·0	About 4·0 ft.
	19·32	20·70	10·0 to 10·7	4·60	111·0	" "
	20·40	21·25			110·0	" "
	21·70	22·60			109·0	" "
	23·05	24·30			107·0	3·5 ft.
	24·80	26·00			105·0	3·0 ft.

EXPERIMENTS ON SIDE LAUNCHING.

Fig. 8. ELEVATION

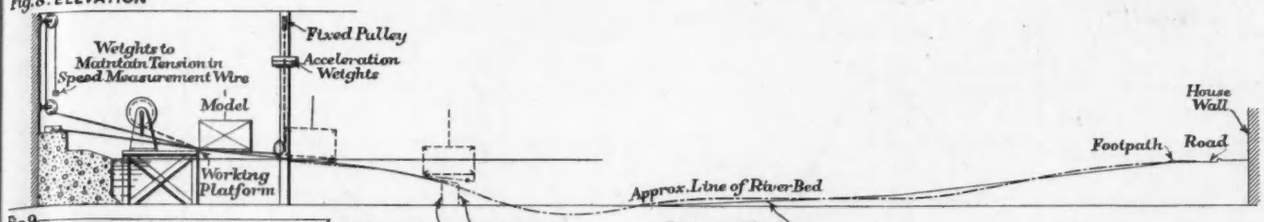


Fig. 9.

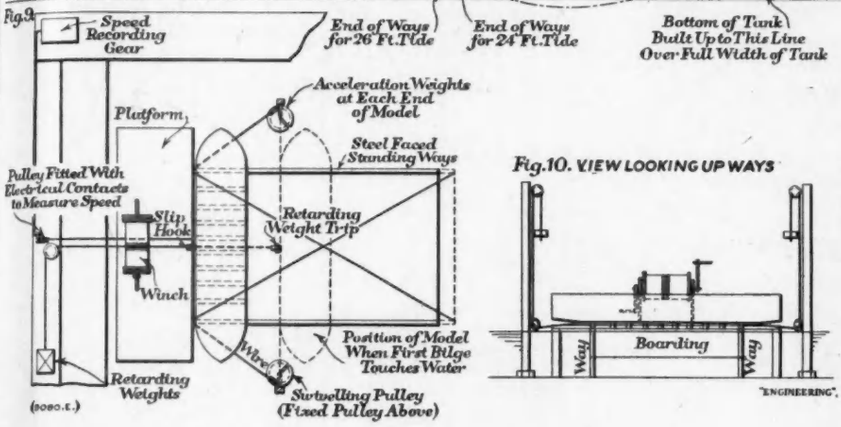
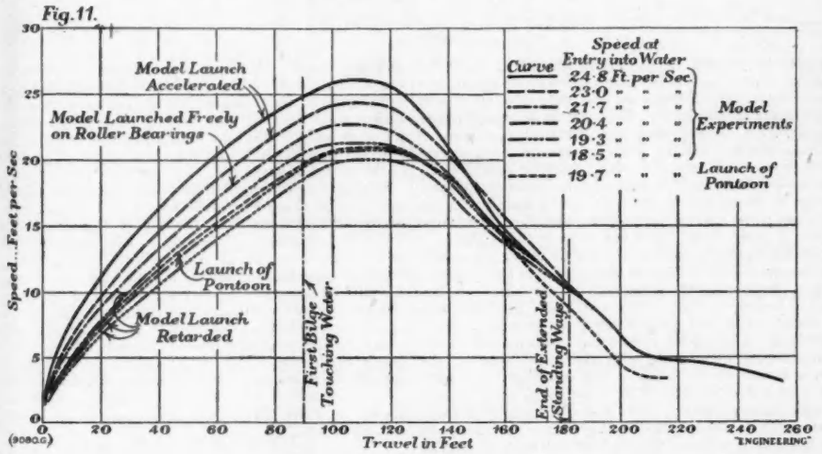

Speed Recording Gear
End of Ways for 26 Ft. Tide
End of Ways for 24 Ft. Tide
Bottom of Tank Built Up to This Line Over Full Width of Tank
Acceleration Weights at Each End of Model
Platform
Steel Faced Standing Ways
Pulley Fitted With Electrical Contacts to Measure Speed
Slip Hook
Retarding Weight Trip
Winch
Position of Model When First Bilge Touches Water
Wire
Retarding Weights
Swivelling Pulley (Fixed Pulley Above)
(9060.E.)

Fig. 10. VIEW LOOKING UP WAYS

Fig. 11.



being built in January, 1943, at Conway, North Wales, as a unit of experimental harbour equipment; an idea which was to grow into the famous Mulberry Harbour. It had to be launched sideways into a narrow river, in which a rapid current flowed between high and low water. The unit would have a launching weight of about 3,155 tons, and, the width of the river being only about 400 ft., the authorities were anxious to explore the possibilities of damage to houses on the opposite shore. The Ship Division of the National Physical Laboratory was therefore asked to construct a model of the river and carry out launching tests to observe the wave formation on the far shore.

The only launching experiments previously made at the N.P.L. were on a lifeboat, launched in the usual end-ways fashion, and doubt was felt, therefore, as to the application of the results of the model tests to the full-size event. The National Physical Laboratory was not responsible for the actual pontoon launching arrangements, the model experiments being solely directed towards predicting the wave formation and its possible effects on the opposite shore. The arrangements for launching and all the necessary calculations were made by the contractors, Messrs. Holloway Brothers (London) Limited, under the general direction of Mr. Iorys Hughes.

The pontoon was a concrete structure of the following principal dimensions:—length, 202 ft. 7 in.; beam, 45 ft. 0 in.; depth, 24 ft. 0 in.; draught, 14 ft. 4½ in.; launching weight, 3,155 tons; estimated G.M. at launch, 2·8 ft. The cross sections were everywhere rectangular, and, in plan, there was a long parallel centre part, covering 68 per cent. of the length, rounded in quite sharply at each end. The photograph reproduced in Fig. 5, opposite, gives a general idea of the whole unit with its large steel-girder superstructure.

The lay-out of the standing ways and the general arrangement of the site are shown in Fig. 6, opposite. There were ten ways, each 3 ft. wide, giving an average pressure of 2·34 tons per square foot. The ways were cambered to a constant radius of 1,480 ft., with a slope at the centre line of the ship before the launch of 1 in 16, and at the extreme end of the ways of 1 in 5, the mean declivity being 1 in 10½. The ways were greased with Tallene launching lubricant. Sperm oil was added on top before the actual launch.

A model of the pontoon was made in paraffin wax to a scale of 1/20th full size, being ballasted with weights to give the correct scale displacement of 861 lb. The weights were distributed so that the pontoon floated level on even keel, and had practically the correct G.M. to scale, as determined by inclining experiments. Some rolling experiments were also made in an attempt to ensure that the model had the same transverse radius of gyration as the pontoon. The shortest period which could be obtained on the model was equivalent to 12·5 seconds for the pontoon, as compared with the estimated period of 11·25 seconds.

Before the experiments were begun, calculations had been made of the probable speed of entry of the pontoon into the water. These were based upon a coefficient of friction for the grease of 0·025, as the result of experiments using approximately the same pressure per square foot between the surfaces as on the pontoon, namely, 2·34 tons. These calculations showed that the vessel would probably touch water at a speed of 18 ft. per second and would continue to accelerate for a very short time until a speed of about 21 ft. per second was reached; and that the water resistance would then cause a fairly rapid deceleration. The remaining work was carried out on the assumption that the speed of entry would be about 18 ft. per second. It subsequently transpired that the experiments to determine the coefficient of friction had been made with Russian tallow, whereas the launch was to be made with Tallene launching lubricant and sperm oil, and it was then decided to extend the model experiments to cover a range of speeds above and below 18 ft. per second.

A considerable amount of preliminary work was done on the launching ways, using different areas of surface and types of grease. It will be obvious that, if an exact scale model were made of the ways, the pressure per square foot would only be 1/20th of that on the ship. In the first place, therefore, experiments were made with only two standing ways, the sliding ways being of the correct length to give the same absolute pressure on the grease surface. All these experiments were failures, and it was finally found necessary to use roller bearings.

The final arrangement of the model apparatus is shown in Fig. 7, opposite, and Figs. 8, 9 and 10, on this page. The standing ways were cambered having a constant radius for the actual model ways of 74 ft., and consisted of two ways, each 1½ in. wide, spaced equally 3·25 ft. on both sides of the middle transverse plane of the model. The ways were of wood, and the top surface was covered with a strip of ¼ in. steel plate. The sliding ways consisted of two iron bars, 1 in. square, fixed to the underside of the model, and inset into each bar were two roller bearings, projecting about ¼ in. below the bar and having a flange width of ⅛ in. The sliding ways were shaped and fitted so that the model was correctly placed as regards height above ways and attitude. In addition, ten dummy sliding ways were attached to the underside of the model in order that the resistance of the launching ways might be comparable in ship and model.

In the remaining description of model tests, all dimensions, speeds and times are given in terms of ship figures, except where stated to the contrary, as being more intelligible and more easily comparable with the full-sized observations.

The experiments were carried out in the shallow end of the New Tank at Teddington, the water level being arranged in the first instance to correspond to a height of tide above site datum of 26 ft. The space between the standing ways was boarded in to very nearly the level of the grease surface for the pontoon, this being the approximate level of the ground and sand at the launching site at that particular time. The shape of the river bed was reproduced approximately by boarding laid on steel scaffolding, and the beach, roadway, garden wall and houses on the opposite bank were made correct to scale for a short length immediately opposite the centre of the launch ways. The general lay-out for the experiments can be seen from Fig. 7, opposite.

It was found that, if the model were released and allowed to move down the ways under gravity only, the speed at entry corresponded to about 20·6 ft. per second, or rather more than the probable speed of the pontoon. To obtain the lower speeds, weights were dragged behind the model during the first part of the launch and the drag cord was released by an automatic trip before the model entered the water, after which she was quite free from any restraint. To reach higher speeds, a wire was taken around the aft side of the launching cradle, brought forward diagonally to points nearly at the water level at each side, and led over swivelling pulleys up to two vertical pulleys, the two ends carrying scale pans on which weights could be placed. When the model was released, the tension in the wire gave it additional acceleration, and, just before it entered the water, the wire became taut transversely across the ways and the model ran clear.

EXPERIMENTS ON SIDE LAUNCHING.

Fig. 12.

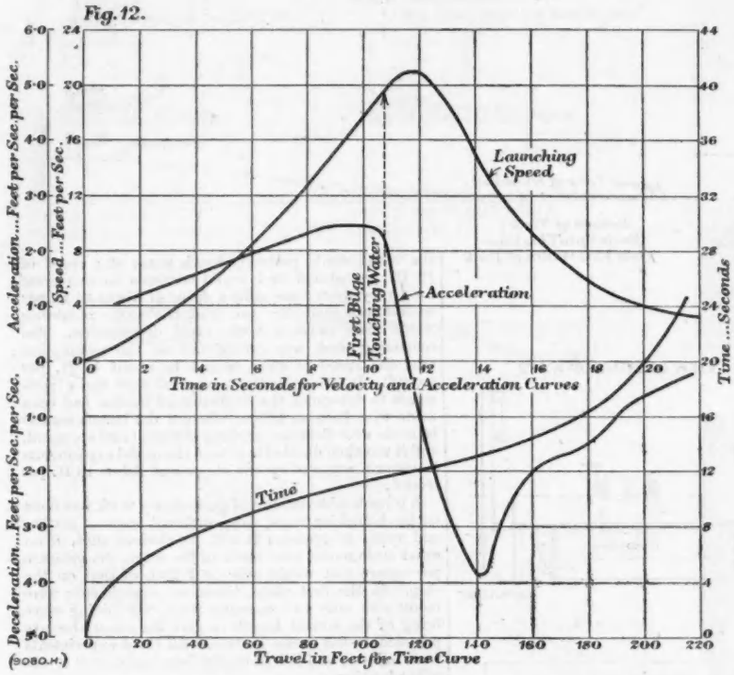
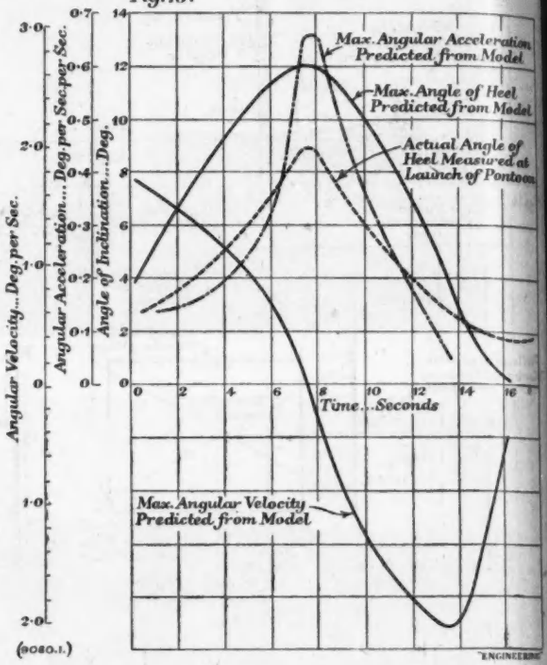


Fig. 13.


Max. Angular Acceleration Predicted from Model
Max. Angle of Heel Predicted from Model
Actual Angle of Heel Measured at Launch of Pontoon
Max. Angular Velocity Predicted from Model
Angular Velocity...Deg. per Sec.
Angular Acceleration...Deg. per Sec. per Sec.
Angle of Inclination...Deg.
Time...Seconds
(9080.I.)
ENGINEERING

A series of tests was made with different drag and acceleration weights to cover the probable ship speeds of entry. During each experiment, records were taken of the distance travelled and the time. Observations were made of the time from release to the model entering the water, and passing the way ends, and to the arrival of the first wave on the opposite shore. Ciné films were taken of the launch, and also of the waves on the beach opposite, a grid being erected at each point for future analysis.

The speeds of entry varied from 17 ft. to 25 ft. per second, in the experiments corresponding to a 26-ft. tide, and the model ran well clear of the ways on every occasion. As she left the way ends, she tipped outwards to an angle of about 12 deg., and the freeboard left from the wave surface at the hull to the deck was only about 3 ft. 6 in. The waves travelled across the river to reach the far shore at times varying between 33 seconds and 42 seconds after the release of the ship, according to the speed of entry into the water. The first wave had a height of 3 ft. 6 in. to 4 ft. at the shore; it ran up the beach, across the roadway and broke against the low garden wall. The "beach" in the experiments was of smooth wood—actually, it was of shingle, which would reduce the wave both because of its roughness and by actual absorption of water through the shingle.

The original date proposed for the launch could not be kept, and on the new date the height of tide above site datum was expected to be only 24 ft. instead of 26 ft. Further tests were made, therefore, with the standing ways lifted vertically a distance corresponding to 2 ft. The length of ways below water was now considerably less than before, and the ship would have a longer run and, therefore, a higher speed of entry. It was observed that the model tipped outwards after leaving the way ends considerably more than with the 26 ft. tide—some 18 deg. in place of 12 deg. It was recommended, therefore, that the standing ways should be extended so as to give the same depth of water over the way ends as with the 26-ft. tide. The maximum possible extension on site was 15 ft., and the corresponding length was added to the model ways and the programme of tests repeated. The records of launching speeds against travel are plotted in Fig. 11, on page 71, and the maximum speeds, speed at entry and other data for both the 26-ft. and 24-ft. tides are given in Table II, on page 70. Curves of speed and acceleration to a base of time are shown in Fig. 12, on this page.

As the pontoon left the way ends, she tilted outwards from her static position on the ways, and as she became waterborne returned to the upright. The change in inclination with time was measured from the films, and curves of maximum values of the angle from the vertical for the experiments with 24-ft. tide are shown in Fig. 13, on this page. The angle did not appear to depend on the speed of entry, since the curves of θ were not arranged in order of speed, but were apparently fortuitous, and only the maximum values are shown in Fig. 13. The maximum angular acceleration derived from the curve of maximum θ is also shown in Fig. 13. The concrete pontoon carried a high steel structure on top, reaching some 50 ft. above the deck, and the acceleration forces on this and upon its anchorage to the deck were a source of some anxiety; the values of maximum angular acceleration were of great value to the designers in this matter.

In the tests, the spaces between the ways were made up to some 5 in. below the top surface of the standing ways, that being the condition on the site when the model tests were done. This was not a fixed condition, however, sand and shingle being continually removed or deposited throughout the year, and some additional experiments were made with the wood between the ways removed completely. The standing ways were then in water of some 40 ft. depth, with only bracing struts between them. There was a much greater space for water to escape under the hull. The principal result was to increase the angle of tilt from 12 deg. to 24 deg.

For similar conditions of accelerating and retarding weights, the speed of entry was some 3 ft. to 4 ft. per second greater with the 24-ft. than with the 26-ft. tide, due to the longer run from rest, as shown in Table II, on page 70. Once the model entered the water, she experienced little further acceleration, because of the resistance offered by the water, both in the form of head resistance on the leading side and eddy resistance behind. Thus, with a speed of entry of 24·8 ft. per second on the 24-ft. tide, the maximum speed was only 26 ft. per second.

The water resistance was greater the higher the speed of entry, and the deceleration was consequently greater also, with the result that, with a 24-ft. tide, the speed as the centre-line passed the way ends only varied from 10 ft. to 10·7 ft. per second, despite a difference of entry speed of from 18·33 ft. per second to 24·8 ft. per second. This effect continued after she was afloat, and the final speed was the same whatever the initial speed of entry, being 4·6 ft. per second after 220 ft. travel on a 24-ft. tide. Thus the experiments indicated that, although the actual speed of entry of the pontoon might vary considerably with temperature and wind conditions of the day of the launch, the speeds passing the way ends and when afloat would be much the same in every case. There was little variation in angle of tilt, the maximum angle for the 24-ft. tide always being between 10 deg. and 12 deg. The maximum angular acceleration during the tilt was 0·65 deg. per second per second.

If the problem of this launch is treated statically, there should be no such tilt, since there was enough water over the way ends to float the model off before reaching them; this was demonstrated by lowering the model slowly down the ways. In the dynamic conditions of the launch, it would appear that the tilting must be about the leading ends of the sliding ways, caused by the very high water resistance acting low down on the hull and the relatively high position of the centre of gravity.

When the model entered the water, a large "breaker" was formed along the whole length of her side. The minimum freeboard from the top of this breaker to the deck is shown in Table II, its least value with a 24-ft. tide being about 3 ft. With no "ground" between the standing ways, the breaker was larger, the model tilted more, and a bulwark had to be erected along the deck edge. The top of the wave in this condition reached as far as 3·3 ft. above the deck edge. There was very little backwash up the berth behind the model as she left the ways. As the model slowed up in the water, the breaker travelled across to the opposite bank, and the times and heights are shown in Table III. The maximum height above still-water level was some 4 ft.

TABLE III.—*Particulars of Wave on Far Side of River.*

Tide Height in Feet Above Site Datum.	Speed of Entry into Water, Feet per Second.	Time from Release of Pontoon to First Wave Reaching Wall on Far Bank, Seconds.	Maximum Height of Waves up Beach, from Still-water Level, Feet.
26	14·55	41·6	2·5
	15·92	39·4	2·0
	17·44	37·1	3·5
	18·32	36·2	4·0
	19·68	34·4	4·0
	22·00	32·6	4·0
24	18·33	40·7	About 4·0 ft. at top of beach.
	19·32	38·9	
	20·40	38·0	
	21·70	36·2	
	23·05	35·8	
	24·80	34·9	

To correlate the model and full-scale data, every endeavour was made to obtain complete records of the real pontoon launch. The travel and speed down the ways were measured by means of a wire attached to the pontoon and carried over a wheel on shore which made electrical contacts as it turned. To measure the angles of tilt, the freeboard at the greatest angle, and the wave on the far shore, records were taken on four ciné-cameras. The launch took place on May 4, 1943, in ideal weather, as near "Tank" conditions as could be desired. The pontoon went off exactly to programme and the model predictions were almost completely fulfilled.

(To be continued.)